DRAFT
ROCKAWAY/NEDONNA BEACH
FOREDUNE MANAGEMENT STUDY

FEBRUARY 1986

Department of Land Conservation and Development

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M E M O R A N D U M

February 20, 1986

TO: Foredune Study Advisory Committee
Interested Persons

FROM: Bob Cortright BC
Dune Study Coordinator

SUBJECT: FINAL DRAFT FOREDUNE MANAGEMENT STUDY
DEADLINE FOR COMMENTS: MARCH 13, 1986
REVIEW MEETING: MARCH 13, 1986

Enclosed for your review and comment are copies of the almost final products for the Rockaway Beach/Nedonna Beach Dunes Management Study. I apologize that it has taken several months to revise earlier drafts of the study and prepare a detailed grading plan. Funding and other problems which we were unable to anticipate are responsible for the delay.

Several documents are enclosed for your review:

A Revised Technical Report -- The Technical Report has been vastly reorganized and expanded from the original drafts you reviewed last year. Information is now divided on an area by area basis.

The Nedonna Beach Grading Plan -- Wilbur Ternyik and FGA have drawn up a detailed site specific grading plan for the Nedonna Beach area (from Manhattan Beach Wayside to the South Jetty). The plan identifies where grading can occur and where graded material may be placed. The plan also recommends standards for placement of sand fencing, fertilization and planting of beachgrass. The plan is intended to be used to obtain County and state approvals for grading of the foredune and implementation of other actions necessary to strengthen the foredune. A rough drawing of the proposed grading plan map is also enclosed. An existing conditions map will be provided with the final document, but it is not ready at this time.

A Revised Foredune Management Plan -- Based on the Technical Report Wilbur Ternyik and I have drafted detailed recommendations for the range of human uses and activities which could affect stability of the foredune. The Management Plan assesses the impacts of each major type of alteration and provides specific management recommendations to be implemented by the County and other units of government.

Tillamook County Beach and Dune Ordinance -- Deborah Brooker has drafted amendments to Tillamook County's zonining ordinance to implement the recommendations of the Grading Plan and the Management Plan.

Maps --The size of the Technical Report and Management Plan maps makes them to expensive to copy or reduce at this time. Copies of the draft maps are available at the Department's office in Salem and through FGA in Portland.

A couple of notes on the material. First, I appreciate the length of the material that we have sent out. I think you will find that the material is well organized and fairly easy to read despite its length. If you have limited time for review please focus your comments on the grading plan or areas of interest to you. Second, many of the illustrations included with the documents are still in draft form, so please excuse any inaccuracies. Also, please feel free to suggest changes to them. Finally, if you have any questions or cannot prepare written comments please feel free to call me or the other authors:

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Wilbur Ternyik	Florence	997-2401
Roger Redfern	Portland	233-2011
Deborah Brooker	Tillamook	842-5511
Fred Glick	Portland	242-1342

REVIEW MEETING

A review meeting is scheduled for March 13 in Salem at the DLCD offices. (1175 Court Street NE) The meeting will begin at 1:30 p.m. and run to 5:00 p.m.

BC:ps
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TECHNICAL REPORT

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PHASE 2 DRAFT
TECHNICAL REPORT ON THE FOREDUNE MANAGEMENT STUDY
FOR THE ROCKAWAY/NEDONNA BEACH AREA,
TILLAMOOK COUNTY, OREGON

INTRODUCTION

PROJECT AREA

This investigation focuses on the Nedonna Beach, Rockaway and Twin Rocks shoreline in northwest Tillamook County (see Figure /). For the purpose of dune management the study area extends from the south jetty at Nehalem Bay on the north to the outlet of Spring Lake and Watseco Creek on the south. To assure adequate consideration of shoreline processes portions of the technical investigation included the area from Cape Meares headland on the south to Neahkahnie headland on the north. However, the focus of the technical report is the area bounded on the north by the south jetty at Nehalem Bay and on the south by the north jetty at Tillamook Bay. The study area includes the beach on the west and the lee slope of the foredune on the east.

The study area is approximately halfway between two basalt headlands, Neahkahnie Mountain and Cape Meares. The 17 miles of beach between the headlands is composed mostly of medium sand. Boulder to pebble gravel and coarse sand occur on the beach near the headlands. Between the headlands the shoreline is generally concave, and the only major interruptions are the jetties at Nehalem Bay

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A glossary of terms is provided in Appendix 1.

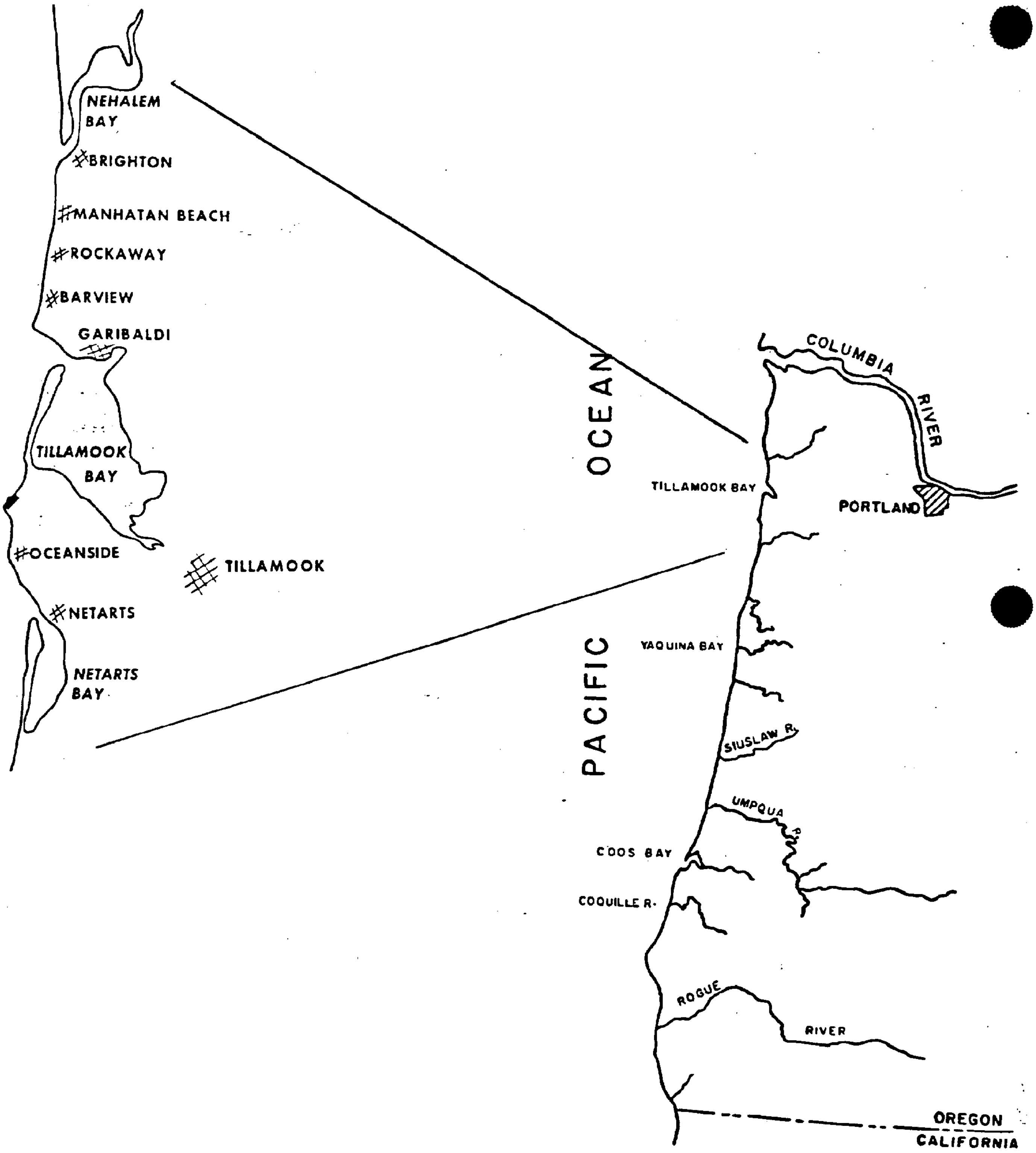

Figure 1. Location Map.

and Tillamook Bay. The only other interruptions to the shoreline are several stream outlets. Except for local zones of erosion the beach is broad and gently sloping. The majority of this shoreline is bordered by a foredune adjacent to the beach.

Sand spits occur at Nehalem and Tillamook Bays. Nehalem spit extends southerly from the mainland at Manzanita and the Tillamook Spit (also known as Bayocean Peninsula and Kincheloe Point) extends northerly from the mainland at Cape Meares. Tillamook Spit was breached near its south end in 1952, and on the spit the Bayocean Resort development was subject to severe erosion beginning about 1920 to 1925 (Dicken, 1961). The resort was eventually abandoned. The breach in the spit was closed by a dike in 1955-1956.

This study is divided into two parts, a technical investigation and report and a management plan. The overall objective is the preparation of a management plan for the Rockaway/Nedonna Beach area which maintains and enhances natural flood and erosion control functions of foredunes and where appropriate allows grading for maintenance of views from ocean front dwellings. It is the purpose of this technical report to review, document and analyze the relevant past, present and potential future physical conditions and processes in the study area that would affect foredune modification.

INVESTIGATION

The investigation included a literature review, discussions with knowledgeable individuals, interpretation of aerial photography, field investigation and mapping, and analysis of the information collected. Important references and personal communications are cited in this report and listed at the end of the report. Aerial photography used in the investigation is listed in Table 1. The upper edge of the beach was plotted on the aerial photos and reproduced on the Technical Report Map. Field investigation results are provided on the Technical Report Map and in the text of the Technical Report.

COASTAL PROCESSES AND FEATURES

In order to set the stage for the foredune management the nature of the hazardous conditions at Rockaway and Nedonna Beach must be recognized. There also must be recognition that without sound foredune management the risk of severe damage from ocean storms is greatly increased.

Man has long had a love affair with the sea and its beauty. However, there are inherent dangers. This is very apparent with most of the beach front homes and commercial buildings in the Nedonna Beach/Rockaway study area. With few exceptions, all of these structures were built on or near an unstable foredune system. (Foredunes subject to continuing wave overtopping, ocean flooding, sand erosion, and sand deposition.) One only needs to look at the past historical erosion events to realize the seriousness of this

Table ~~8~~ 1: Aerial Photos Used in the Rockaway/Nedonna Beach Dune Management Study

Date	Photo Numbers	Type[1]	Scale	Source[2]
4-28-39	39--1555 to 1567	B&W	1:10,200	Corps
8-20-64	64--2198 to 2203	B&W	1:10,000	Corps
8-17-66	66--2220 to 2223	B&W	1:30,000	Corps
5-17-69	TGI 1--16 to 18	B&W	1:45,000	ODOT
6-24-70	TIB 11--1-3 to 1-12	B&W	1:24,000	ODOT
7-25-73	OC-17--15-6 to 15-14	C	1:12,000	ODOT
7-25-73	OC-17--16-1 to 16-5	C	1:12,000	ODOT
12-26-77	77-2363 to 2368	B&W	1:24,000	Corps

[1]B&W - Black and White;
C - Color.

[2]Corps - U. S. Army Corps of Engineers;
ODOT - Oregon Department of Transportation

problem.

On December 2 and 3, 1967:

> "In Tillamook County, logs were washed a block behind the oceanfront road at Manzanita. Nehalem faced its worst flooding since 1933 with nearly every business building in the the main block being flooded. Waves carried logs over the sand dune and blocked the parking lot at the north end of Nedonna Beach, and damaged homes at Manhattan Beach. At Rockaway, the surge sent logs over the railroad tracks and onto U.S. Highway 101, damaging several houses, plugging the creek outlet and causing local flooding. Logs damaged houses at Twin Rocks and were carried across the railroad tracks to the highway there. At Bar View in Garibaldi, logs washed into Highway 101. Flooding occurred near the Miami River and some highway flooding occurred near Tillamook. Logs were washed nearly two blocks back from the beach at Cape Meares, and logs damaged homes, seawalls, and riprap at Netarts. Picnic tables were washed away at the county park at Sandlake, and logs were strewn across the highway at Tierra Del Mar. Although many houses and buildings in Pacific City and woods were surrounded by water, no damage was reported. At Camp Winema, logs were washed high above the beach, but no damage was done to the buildings; and at Neskowin, logs damaged beachfront houses."
>
> "Historically, one of the greatest ocean floodings in Tillamook and Clatsop Counties occurred on January 3, 1939, when high tides and windswept waters caused extensive damage over much of coastal Oregon. The sandspits at Bayocean and Neskowin Ridge were breached in several places, and surf-swept logs damaged dozens of beachfront houses at Twin Rocks, Manhattan Beach, Tierra del Mar, and other communities. South of Barview, 300 feet of Southern Pacific Railway track were carried inland over Highway 101. Waves splashed completely over Twin Rocks, one-half mile offshore from the community of Cape Meares. In calm weather, Twin Rocks and Pyramid Rock stand 80 to 100 feet, respectively, above mean sea level." (Schlicker and others, 1972, page 103)

Past storm events, such as those of 1967 and 1939, indicate the probability of future storm-induced erosion and flooding.

Given the inevitability of future ocean flooding, it is imperative that appropriate measures be taken as soon as possible to strengthen natural storm wave defense systems in developed areas. In numerous other parts of the world, there is a clear recognition of the protective nature of foredune areas as a buffer zone against attack by the sea. The U. S. Army Corps of Engineers reports:

> "While the sloping beach and beach berm are the outer line of defense to absorb most of the wave energy, dunes are the last zone of defense in absorbing the energy of storm waves that overtop the berm. Although dunes erode during severe storms, they are often substantial enough to afford complete protection to the land behind them. Even when breached by waves of a severe storm, dunes may gradually rebuild naturally to provide protection during future storms. Continuing encroachment on the sea with manmade development has often taken place without proper regard for the protection provided by dunes. Large dune areas have been leveled to make way for real estate developments, or have been lowered to permit easy access to the beach. Where there is inadequate dune or similar protection against storm waves, the storm waters may wash over low lying land, moving or destroying everything in their path.
>
> "Gently sloping shores, whether beaches or wetlands, are natural defenses against erosion. The slopes of the foredune form a first line of defense, dissipating the energy of breaking waves. The berm prevents normal high water from reaching the backshore. Dunes and their vegetation offer protection against storm-driven high water and also provide a reservoir of sand for rebuilding the beach. Wise management of shore areas should include protection of these natural defenses where they exist.
>
> "Although erosion is essentially caused by natural shoreline processes, its rate of seveity can be intensifed by human activity. The shoreline and the water are highly valued for recreational activities, but heavy use and development may accelerate erosion. Those who build 'permanent' homes and recreation facilities often ignore the fact that the shoreline is being constantly built up and worn away again. They may also fail to take into account the periodic and unpredictable effects of storms." (U.S. Army Corps of Engineers, 1975)

In Europe, where some dune areas have been intensively managed for years, foredunes, referred to as barrier dunes, are given prime consideration because of their protective nature.

> "On sandy coasts, the ridges of sand dunes are often the natural protective structures against flooding the low-lying land, the villages or towns during storm tides. The strength and resistance of these barrier dunes, which are found just landward of the beach, is to be estimated in consideration of the extent and the height of the dunes as well as of the width, the height and the stability of the beach. As in many cases on the beach in consequence of altering sea and wave conditions and different littoral drift, the supposition for erosion or aggradation varies, dunes and beaches have to be observed constantly. The beginning of a considerable erosion of the dunes has to be seen in connection with the development of the beach. A systematic research of the reasons and the further development has to be done. The research has to include the total dune-beach-profile." (Erchinger, Heie. Protection of Sandy Coasts in 1974. Dependence of the Dune-Beach-Type)

In West Germany annual erosion of foredune foreslopes is repaired each season. Erchinger also speaks to repair of eroded foreslope in the Netherlands on the Isle of Tuxel by use of bulldozers followed by replanting of stabilizing vegetation.

Grading the foredune for ocean viewing was the impetus to cause this study to take place, but the ultimate benefit will be strengthening the protective nature of the foredune through informed management.

Two concepts that are critical to foredune management emerge from the national and international literature:

1. Sand in the nearshore, beach and foredune is part of a dynamic, constantly changing system. Whether in the offshore bar, nearshore slope, beach, beach berm, or foredune, the sand is critical to the stability of the

shoreline.

2. Typically the foredune is above the level of high tides and most waves. The foredune is composed of sand in storage; sand that is available to protect inland areas from severe storm surges and storm waves.

Maintenance and enhancement of the foredune and natural beach-dune processes is critical because of the protective function of this system against ocean flooding. If the foredune is damaged or the natural system disrupted the potential for flood damage to beach front development is increased. The beach and foredune respond to ocean flooding in a predictible way:

> "The natural beach exists in a state of dynamic tension, continually shifting in response to waves, winds, and tide and continually adjusting back to equilibrium. Long-term stability is gained by holding the slope or profile intact through balancing the sand reserves held in various storage elements - dune, berm, offshore bar, and so forth. Each component of the beach profile is capable of receiving, storing, and giving sand, depending on which of several constantly changing forces is dominant at the moment. Stability is fostered by maintaining the storage capacity of each of the components at the highest level.
>
> "When storm waves carve away a beach, they are taking sand out of storage. In the optimum natural state there is enough sand storage capacity in the berm or dune to replace the sand lost from the beach to storms. Consequently, the effects are usually temporary, with the dune or berm gradually building up again." (Clark, 1977,pp. 320-323)

Clark also explains the role of dunes in this protective function:

> "As the dune is attacked by storm waves, eroded material is carried out and deposited offshore, where it alters the underwater configuration of the beach. Accumulating sand decreases the offshore beach slope (makes it more nearly horizontal), thereby presenting a broader bottom

> surface to storm wave action. This surface absorbs or dissipates through friction an increasingly large amount of destructive wave energy that would otherwise be focused on the shoreline behind the barrier.
>
> "The capacity of the dune for absorbing and moderating wave energy is not dependent on any ability to completely prevent breaching or flooding. Even in the process of being inundated and destroyed, as many are by hurricanes, the dune moderates back beach storm damage. This effect is less pronounced for low dunes, but nevertheless persists. Since storm resistance increases with dune height, however, all human uses of the barrier that devegetate, erode, or lower the dune expose the shoreline behind the barrier to increased storm damage." (Clark, 1977, 67)

The effectiveness of unaltered dunes in providing protection from flooding is a principal reason for the prohibition on building on undeveloped foredunes subject to ocean flooding or erosion. Although foredunes in the study area have been altered their flood protection capability has not been completely compromised. Several areas have eroded or are eroding without imminent threat of damage to existing homes. Nonetheless it is likely that some areas will experience erosion that, if unchecked, will damage or destroy structures. (North Nedonna Beach experienced this kind of heavy erosion in 1970-71 and 1978-79.)

This section summarizes regional information relevant to the study area. It is the purpose of this section to provide the basis for the understanding site-specific information presented in the following sections.

OFFSHORE PROCESSES

The offshore processes, features and hazards that are relevant to this area and study are tides and waves, offshore bars, and nearshore current.

Tides are an important shoreline altering process when combined with storm surges, large waves, and rip-current embayments. Episodes of beach and foredune erosion occur in periods of high tide particularly when combined with storm surges and large waves. Figure 2 illustrates the range of tidal elevations on the Oregon Coast. The lowest estimated tide that can occur is 3.5 feet below mean lower low water (about 7.6 feet below mean sea level). The highest tide predicted by tide tables is 10.3 feet above mean lower low water (about 6.2 feet above mean sea level). The highest tide projected to occur, the sum of the highest predicted tide and the highest recorded storm surge, is 14.5 feet above mean lower low water (about 10.4 feet above mean sea level).

Waves provide the energy for beach and nearshore sand movement and for erosion of the beach and foredune. Waves are generated by winds and reflect seasonal variations in weather patterns.

The nearest published wind rose diagram is for Tillamook. Figure 3 shows wind roses for the typical winter and summer months of January and July. In January, the major wind directions are from the south and southeast, but there are also significant winds from the east. In July, the majority of winds are from the northwest, but there are also notable winds from the north and west.

In general, waves approach the Oregon Coast from the southwest in the winter and from the northwest in the summer. Wave period and breaker height vary seasonally; in both cases

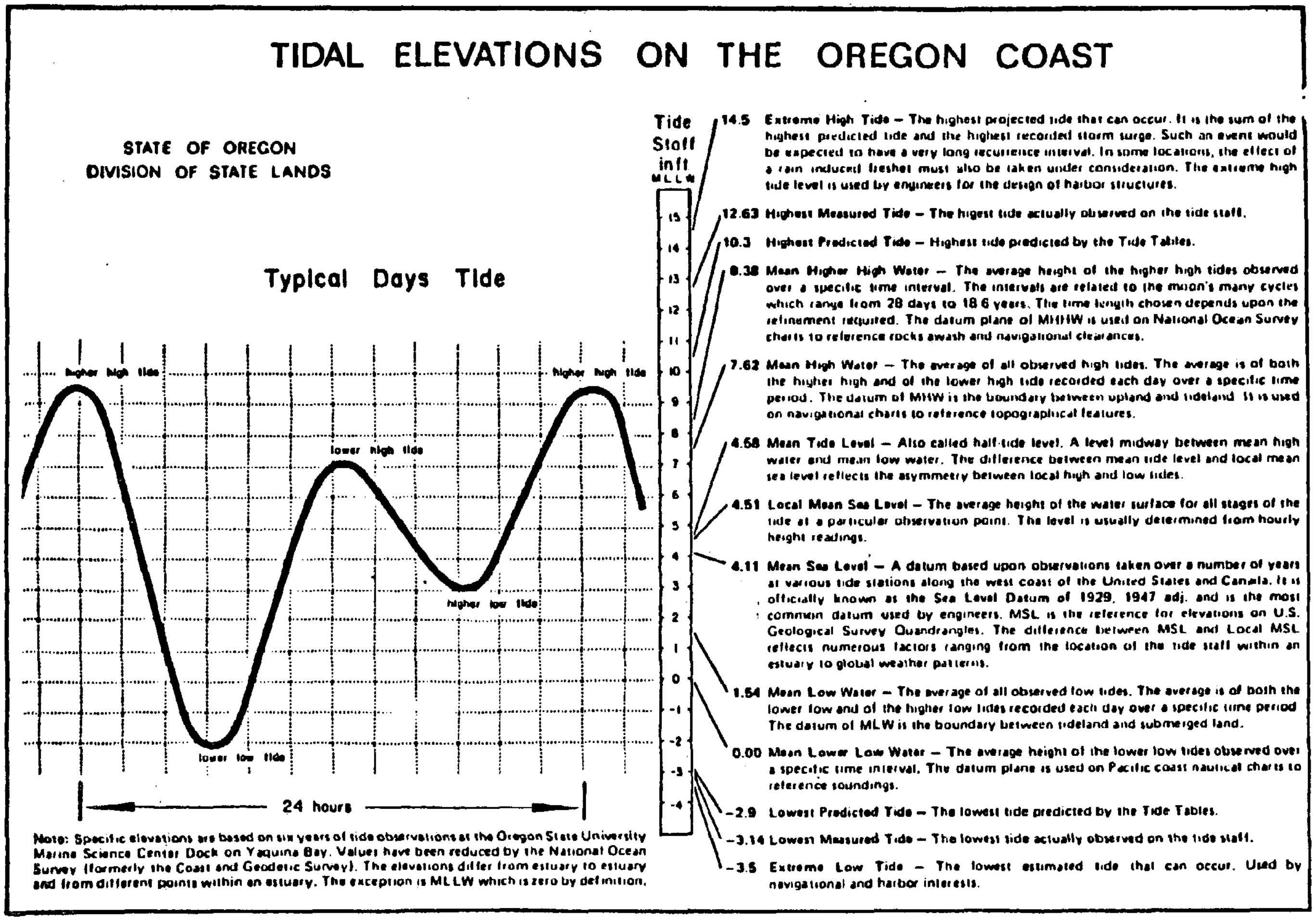

Figure 2. Tidal elevations as measured in Yaquina Bay (from Hamilton, 1973).

Figure 3. January and July wind roses for selected sites. This plate was provided by the Portland District, U.S. Army Corps of engineers.

they are higher in the winter and lower in the summer.

Wind speed, wind duration and the extent of ocean exposed to the wind influence wave height and frequency. The wind direction influences wave direction. Waves can be generated by both local and distant storms. Wave conditions have been studied by O'Brien (1951) on the Columbia River lightship and studied on offshore oil drilling rigs by Rogers (1966) and by Watts and Faulkner (1968). Offshore wave heights of up to 58 feet were reported and one exceptional wave was reported as 95 feet high. According to Komar and others (1976b): "The measurements of both Rogers (1966) and Watts and Faulkner (1968) do not represent average wave conditions during the severe storms, but exceptional waves produced by the chance constructive summation of several large waves." On the shoreline, the constructive summation of two or more waves can produce what is called a freak wave or sneaker.

In 1971, a seismic recording system was installed at the Marine Science Center at Newport. Komar and others (1976b) present a summary description of the system and its limitations and provide an analysis of recorded measurements from November 1971 through June 1975. Figure 4 illustrates significant wave breaker heights from July 1972 through June 1973. This figure includes large storm waves produced in December 1972 that resulted in significant erosion on the shoreline. The maximum wave breaker height measured was 7

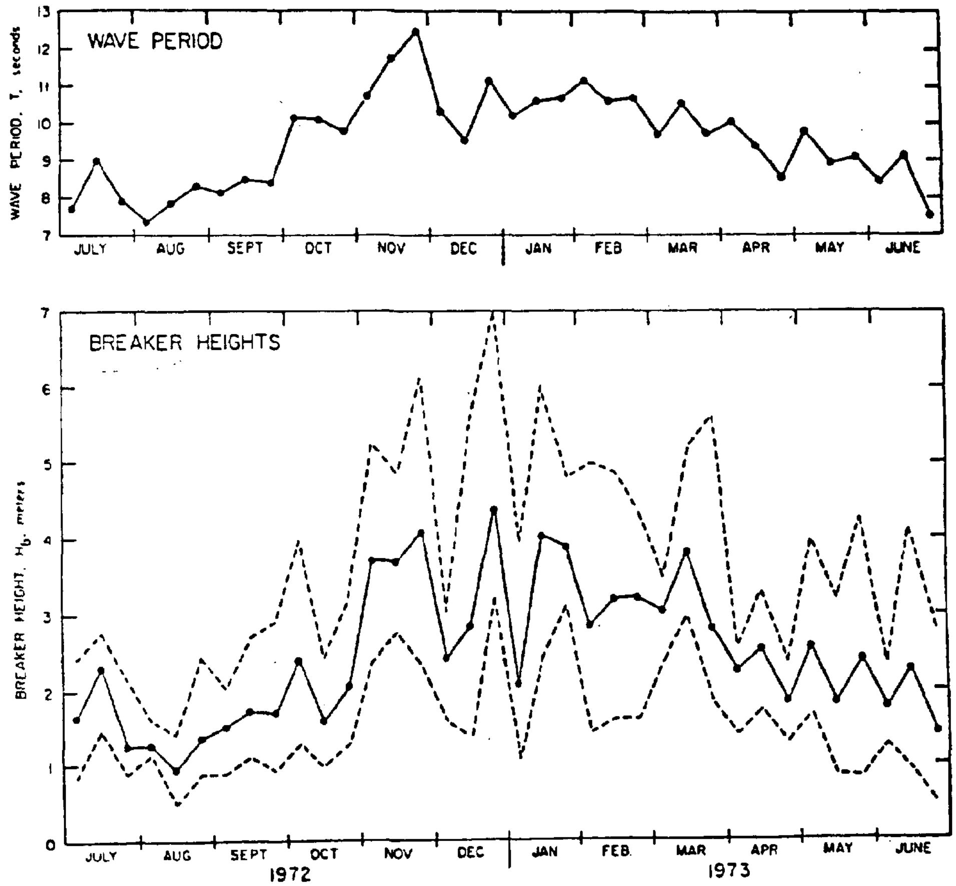

Figure ~~10~~ 4. Significant wave breaker heights and periods measured at Newport during July 1972 through June 1973. Each datum point gives the average for one-third month. The dashed lines give the maximum and minimum breaker heights during those one-third month intervals. Note the arrival of large storm waves during the last part of December 1972. (From Komar, 1979).

meters (23 feet). Average height of the larger breaking waves was estimated by Komar (1979) as about 15 feet. He also noted that heights of 23 feet are truly exceptional and that similarly high breakers were recorded in December 1972, October 1977 and February 1978 which were periods of severe shoreline erosion. Similar extreme wave heights were recorded more frequently for storms during the 1981 to 1984 El Nino episode. The evidence gives support to the somewhat obvious observation that large waves, especially on high tides, are largely responsible for shoreline erosion. Another reasonable conclusion is that moderate-sized breakers, days or weeks before a series of large breakers, can set up conditions for severe erosion. (Note the November breaker heights on Figure 4.) The first storm removes sand from the beach and enlarges rip-current embayments, allowing subsequent high tides and large breakers to come closer to the backshore and foredune before breaking and losing energy.

The seasonal variation in wave conditions produces changes in the nearshore zone and beach (Figure 5). High and frequent waves in winter months erode sand from the beach and deposit the sand in offshore bars. In the summer months, the sand in the offshore bars is moved back on to the beach. Because this sand movement is controlled by wave conditions, this cycle is not strictly seasonal. Low waves during the winter will move sand onshore.

Littoral currents are caused by waves that generally approach the Rockaway/Nedonna shoreline from the northwest in

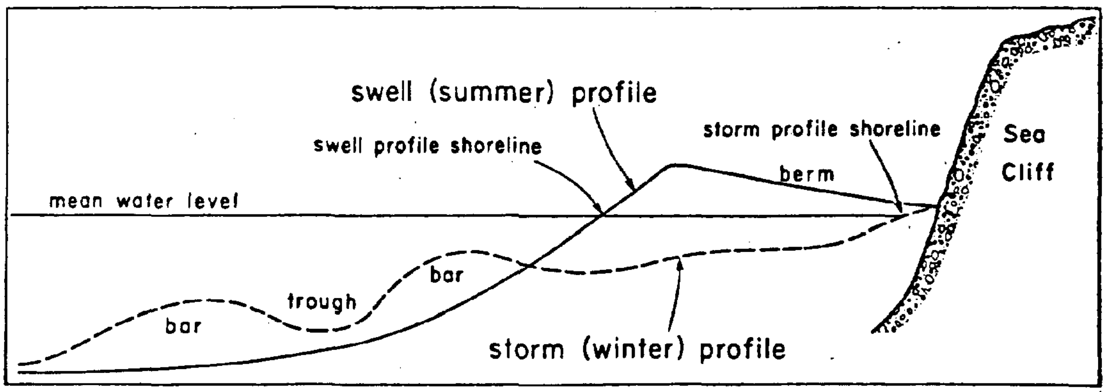

Figure 5. Schematic illustration of the beach profiles produced by storms versus gentle swell waves. On the Oregon coast these profile changes are approximately seasonal due to our storms occurring principally during the winter months. (From Komar, 1979).

the summer months and from the southwest in the winter months. Waves push sand up the beach and the retreating water takes sand off the beach. The result is net movement of sand to the south in summer and to the north in winter. Aerial photos, field evidence, and previous studies (Komar and others, 1976a and Lizarraga-Arciniega and Komar, 1975) indicate that this shoreline has both north and south littoral transport but that the long-term sum of the transport (net drift) is zero or near zero.

Field evidence also indicates that there has been an apparent short-term net northerly drift in the recent past (at least in 1983 and 1984). The primary evidence of this is shoreline erosion north of Cape Meares, north of the Tillamook North Jetty, and north of the Nehalem North Jetty. This evidence is not conclusive, but increased sand on the beach at Neahkahnie, north of the study area, strongly supports a short-term net northerly drift. Recent rehabilitation of the Nehalem jetties and recent extension of the south jetty at Tillamook Bay could explain some of the recent erosion but does not explain the accretion at Neahkahnie.

Rehabilitation of the Nehalem jetties has caused accretion adjacent to the jetties. Typically, the sand supply loss related to jetties is made up by nearby shoreline erosion (Komar and others, 1976a). The accretion at Nehalem jetty has not caused any notable backshore or foredune erosion in the study area, but comparison of 1978 and 1984 aerial photos does indicate a reduction in beach width south of the accretion area near Crescent Lake Outlet.

At Tillamook Bay, the extension of the south jetty was followed by adjacent accretion. There has also been substantial erosion north of the north jetty and moderate erosion south of the accretion area. The erosion north of the jetty could be related to blockage of northerly sand movement around the newly extended south jetty in the winter. However, some experts, including Komar (personal communication) believe that there is very little or no sand transport around jetties.

We concur with Komar's theory that there is a net northerly littoral drift associated with El Nino caused changes in the number of large waves from the southwest. He is investigating the impacts of the recent El Nino. Komar argues that accretion at the south jetties of Tillamook and Nehalem Bays and at Neahkahnie (observed by the study team) is evidence of net northerly drift caused by El Nino. He also believes that since their construction the Tillamook and Nehalem jetties and outflow from the bays has blocked longshore transport, and the extension of the south jetty did not cause the erosion to the north.

Rip currents do develop along the shoreline of the study area and the embayments (cusps) that form are often related to local shoreline erosion (Figure 6). Rip current channels and embayments were observed on aerial photos and in field investigations. The locations were transferred to the

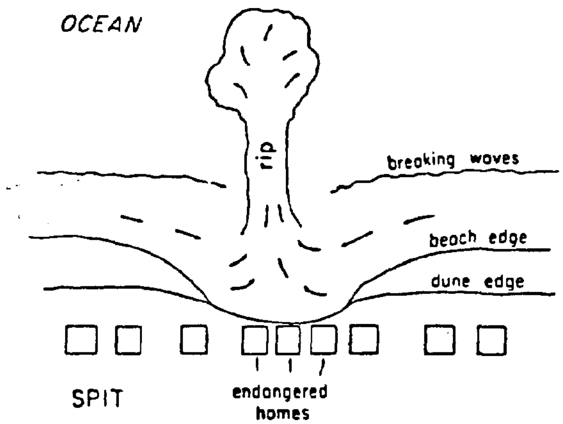

Figure ~~4~~ 6. A rip current flowing outward across the beach hollowing out an embayment into the beach and eventually into the foredunes causing property losses. (From Komar, 1979).

Technical Report Map to determine any patterns of rip current reoccurrence. This evidence indicates that in some locations rip currents can be somewhat stationary. Typically, rip currents would be stationary adjacent to stationary shoreline features such as jetties and the deltas at the mouths of creeks. In other areas, the rip currents do not follow an identifiable pattern.

Previous to the rehabilitation of the Nehalem jetties, rip current embayments were common along the northern portion of the Nedonna Beach area. In 1977 and 1978, two embayments reduced the width of the beach and thereby contributed to foredune erosion that threatened several homes located on the backslope of the foredune. Emergency riprap was placed to protect the homes (see Tecnical Report Map). Slightly north of Rock Creek, a rip-current embayment appears to have contributed to recent foredune erosion that was still evident in 1985 as a large erosion escarpment. In the mid-1960's, an embayment slightly north of Saltair Creek appears to have contributed to shoreline erosion that extended almost to the 1939 shoreline. Slightly north of Spring Lake Outlet an embayment possibly contributed to foredune erosion in the winter of 1982-83. Other specific erosion episodes could probably be related to rip-current embayments but the aerial photo coverage of the study area is only available for a limited number of years (Table 1).

A tsunami is a wave or set of waves produced by a submarine earthquake or volcanic eruption. The term "tidal wave" is sometimes inappropriately used in reference to tsunami. In recent history, the most common source of tsunami waves on the Oregon Coast is the Alaska area. The most recent tsunami events affecting the Oregon Coast occurred in 1964 and 1968 (Schatz and others, 1974 and Wilson and Torum, 1968). Figure 7 illustrates maximum wave heights at several locations on the Oregon Coast including Nehalem and Tillamook Bays for the 1964 tsunami. The largest wave at Nehalem Bay was about 12 feet in height. The low wave heights at the Tillamook River are indicative of the loss of wave energy as the tsunami passed through the broad and shallow bay.

There is solid evidence of a slow, world-wide rise in sea level. A change in sea level could have substantial consequence on shoreline erosion and the long-term safety of the study area. Evidence accumulated by Hicks (1972) suggests that there was a rise in sea level of about 1.5 mm (0.06 inch) per year in the 34 years of records analyzed. However, these records indicate that the Oregon Coast may be rising at about the same rate as the rise in sea level (Figure 8). Records at Astoria, Crescent City in California and Friday Harbor in Washington show no apparent sea-level changes (Hicks, 1972). Alaska is rising faster than the rise in sea level.

There is presently a controversy regarding an increase in the rate of world-wide sea level rise. Hicks (1978) has updated his previous data, but he only reports on the average

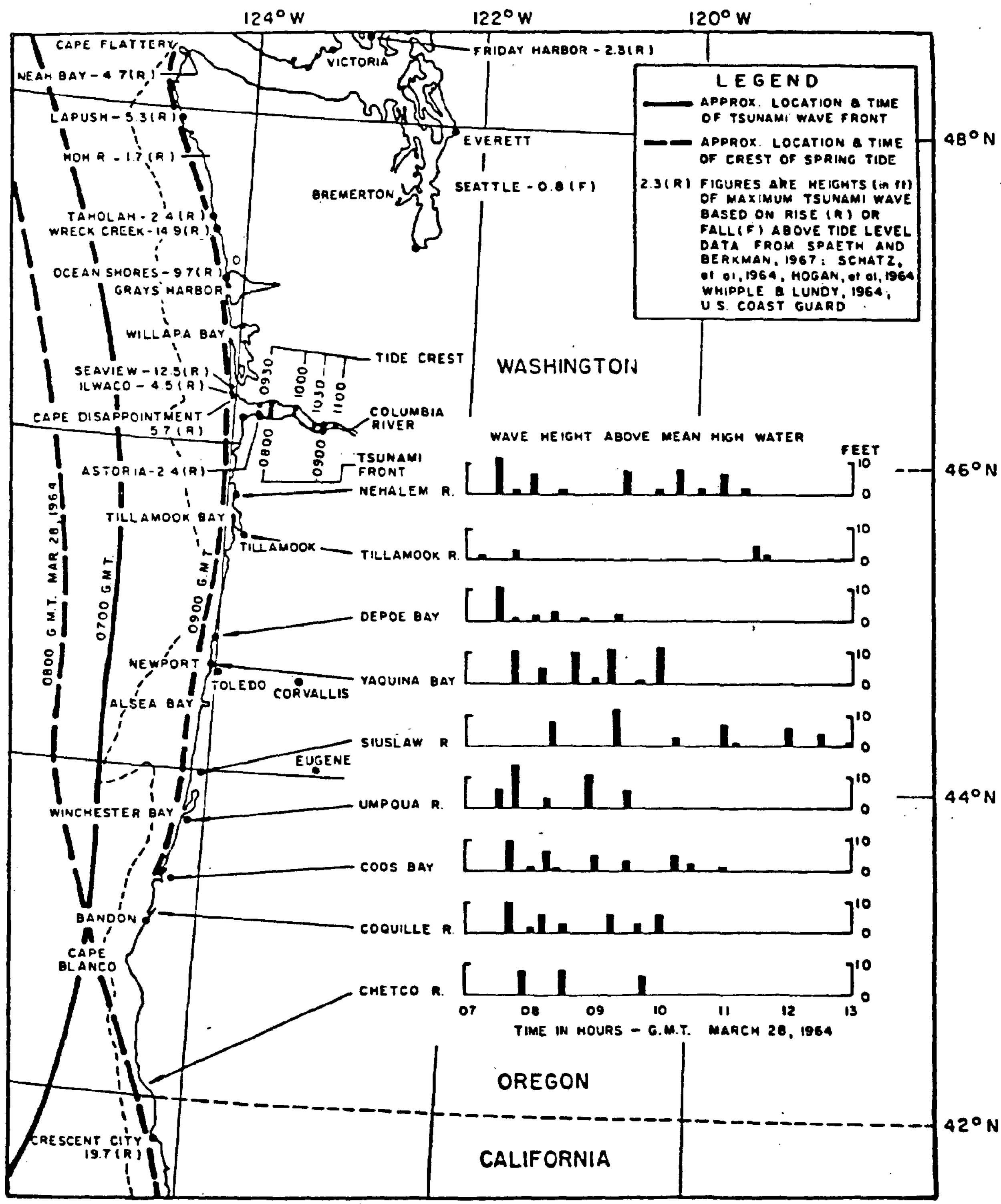

Figure ~~5~~ 7. Maximum heights of tsunami waves recorded at tide stations or by observations along the Washington-Oregon coast (from Wilson and Torum, 1968).

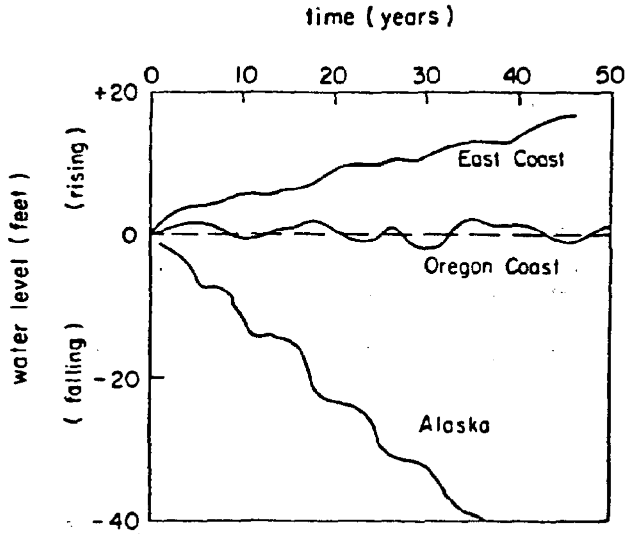

Figure 8. Schematic of water level changes on the Oregon coast as compared to the East coast and the coast of Alaska, based on the data of Hicks (1972). (From Komar, 1977).

rise. Gornitz and others (1982) proposes that there is an increase in the rate of sea level rise related to the Greenhouse Effect. Barnett (1984) disagrees with Gornitz. This controversy promises to continue. If the rate of sea level rise is increasing and continues then Oregon's shoreline will be affected at some time in the future. Because the sea level rise will be initially very slow and very small, there will be sufficient time to re-evaluate foredune grading practices and to react to the growing threat to low-lying coastal areas.

SAND SUPPLY

Information on nearshore bathymetry (water depth) of the study area is limited to a navigation chart produced by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey (1982). The chart, reproduced in part in Figure __, shows water depths at the time of sounding at the Nehalem Bay outlet in 1982, South of the Nehalem bar area, the depths are from 1956 surveys. Because the information illustrates the depths at only the time of the soundings, it is not possible to determine seasonal changes of the offshore bottom or the changes over a number of years.

The chart does indicate the occurrence of sand bars at the time of the soundings. At the mouth of the Nehalem, the bar extends about 2,100 feet beyond the jetties and appears to influence the offshore area for about one mile north and south. The shallow depths at the Nehalem bar (1 to 8 feet) indicate that some sand may have been able to bypass the jetties and the mouth before the rehabilitation of the jetties. Increased scouring of the bar after jetty rehabiliation has probably eliminated sand bypass.

South of the bar at the mouth of the Nehalem Bay, the chart depicts sand bars as far south as the area offshore from Lake Lytle. From there on south, there are no sand bars mapped. It is not known whether the sand bars were not present or had moved inland beyond the survey area. The latter is more likely.

Factors of the littoral sediment budget are illustrated in Table ~~1~~ 2. Littoral transport into the area is apparently blocked by Cape Meares headland on the south and by Neahkahnie headland on the north. Cape Meares is a headland with a precipitous shoreline that extends over 200 feet west of the sandy shoreline. The offshore depth is shown as rapidly dropping off to 18 feet on the U.S. Geologic Survey topographic map. Neahkahnie headland has a precipitous shoreline that extends over 5000 feet west of the sandy shoreline. The jetties and channels at Tillamook and Nehalem Bays apparently also block littoral drift. This creates a pocket beach with a fixed sand budget. River and stream transport from upland areas appears to be negligible or very small (Kulm and Byrne, 1966). The streams do return wind-transported sand to the beach and nearshore system. Some new sand does come from the Astoria Formation sandstone on the north side of Cape Meares headland but does not contribute

Table ~~1~~ 2. The Budget of Littoral Sediments (Adapted from Komar, 1979)

Credit	Debit	Balance
Longshore Transport into Area	Longshore Transport Out of Area	Beach Deposition or Erosion
River Transport	Wind Transport Out	
Shoreline Erosion	Offshore Transport	
Onshore Transport	Deposition in Submarine Canyons	
Hydrogeneous Transport	Solution and Abrasion	
Wind Transport onto Beach	Mining	
Beach Nourishment		

sand to the study area because of the apparent blockage at the Tillamook Bay jetties. Onshore transport might occur seasonally.

The amount of sand lost to offshore transport is not known. Wind does transport some of the sand inland to the foredune. As the foredune continues to receive sand deposits from the beach, there is a net temporary loss to the system. There is ocean wave erosion on the frontal area of the foredune, but there is slow accretion. The amount lost to solution and abrasion is not known, but it is probably very small. The amount of sand removed in the past by mining is not known at this time, but it is probably negligible.

The apparent stability of the central Rockaway shoreline over the last 46 or more years indicates that there are no large supply increases or losses. Our conclusion is that the shoreline segment between the Tillamook and Nehalem jetties has had a roughly steady sand budget. There are no known sources of new sand. A small amount of sand may be added to the system by streams that do not flow through the lakes, Watseco Creek and Rock Creek. There may be a net loss or gain from onshore or offshore transportation, but further detailed study of the offshore bar and sand supply over time is needed to determine the dynamics of bar movement and the volume of sand in relation to the rest of the shoreline system.

Inland sand losses are more apparent. Accretion after the construction of the jetties removed a substantial volume of sand from the system. Slow accretion and foredune growth, since at least 1939, has removed a much smaller amount of sand from the active sand budget.

From the discussion it is evident that much more information is needed on the sand budget in the study area. The necessary information must be obtained through research that is beyond the scope of this investigation. More research is needed on all aspects of the littoral sediment budget. Even a qualitative evaluation on this shoreline is limited by a lack of information on the shoreline and nearshore previous to the placement of jetties at Tillamook Bay and the Nehalem River.

The following is presented as a summary of the best available information as applied to and in evidence in the study area:

1. The condition of the study area shoreline before construction of the jetties at Tillamook and Nehalem Bays is not known. It can be assumed that there was a broad bay mouth at the approximate location of the jetties. It is also assumed that there was a broad beach on the Rockaway shoreline that was backed on the east side by a well vegetated barrier dune ridge, the remnants of which are still present.

2. When the south jetty was constructed at Nehalem Bay in 1915 and the north jetty was constructed at Tillamook Bay in 1912 there was accretion in the low-lying embayments adjacent to the jetties. The source of the

sand needed to fill these embayments is not known. It must be assumed that the sand came from the shoreline between the two bays (i.e. central Rockaway Beach) and/or from the offshore bar.

3. After the accretion associated with the jetty construction the study area established a new equilibrium condition that was subsequently disturbed by the rapid deterioration of the Nehalem jetties.
4. The introduction of European beach grass in the 1930's modified the shoreline character, but it did not significantly alter the shoreline equilibrium. The beach grass created a foredune ridge where previously there had been a broad backshore area.
5. Since the introduction of European beach grass there has been slow episodic accretion in all of the foredune management units, but there has not been a consistent pattern of accretion near the creek mouths. In this time period of slow accretion there has not been a significant diminishing of the beach width. It is not known whether there has been a diminishment of the nearshore profile or offshore bar.

BEACH PROCESSES

Figure 10 illustrates the typical features of a sand beach and the names of the features. The offshore bar is not illustrated.

"The natural beachfront exists in a state of dynamic tension, continually shifting in response to waves, winds,

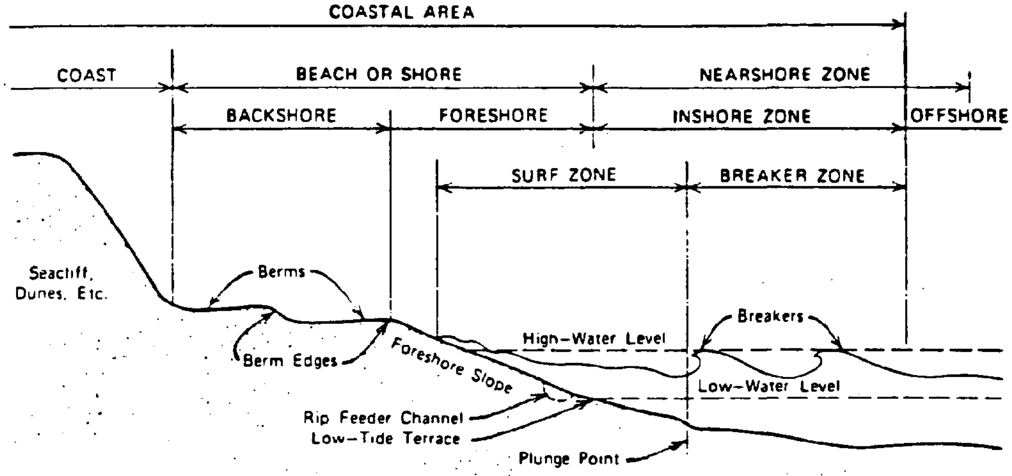

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Figure 7. Features of a typical sand beach. (From U. S. Army Corps of Engineers, 1971).

and tide and continually adjusting back to equilibrium." (Clark, 1977, pp. 320) The components of the typical sand shoreline store sand to defend against wave attack. Figure 11 shows sand removed from beach and foredune storage moves to the nearshore and is stored there as nearshore accretion and offshore bars. With the return of gentle swells, the stored sand is then moved back on to the beach.

The energy used to move sand off the beach and out of the foredune reduces the energy of the attacking waves. Clark further describes the shoreline protective aspect of this sand movement under wave attack:

> "Eroded materials is carried out and deposited offshore where it alters the beach's underwater configuration. Accumulating sand decreases the offshore beach slope (makes it more nearly horizontal), thereby presenting a broader bottom surface to storm wave action. This surface absorbs or dissipates through friction an increasingly large amount of destructive wave energy which would otherwise be focused on the shoreline behind the barrier." (Clark, 1977, pp. 322)

The offshore bar also provides protection from wave attack:

> "Where the land meets the ocean, nature has provided the shore with a natural defense against the attack of the waves. The first defense against the waves is the sloping nearshore bottom which dissipates the energy or weakens the force of the deepwater waves. Yet some waves continue toward the shore with force and energy still at tremendous levels until they near the beach. There they break, and unleash most of their destructive energy. This process of breaking often builds in front of the beach another defense in the form of an offshore bar which helps to trip following waves. The broken waves reform to break again and may do this several times more before finally rushing up the foreshore of the beach. At the top of wave uprush a ridge of sand is formed and serves as a defense against uprush of following waves. Beyond this ridge, or crest of the berm, lies the flat beach berm which is reached only by higher storm waves." (U.S. Army Corps of Engineers, 1971, pp. 7)

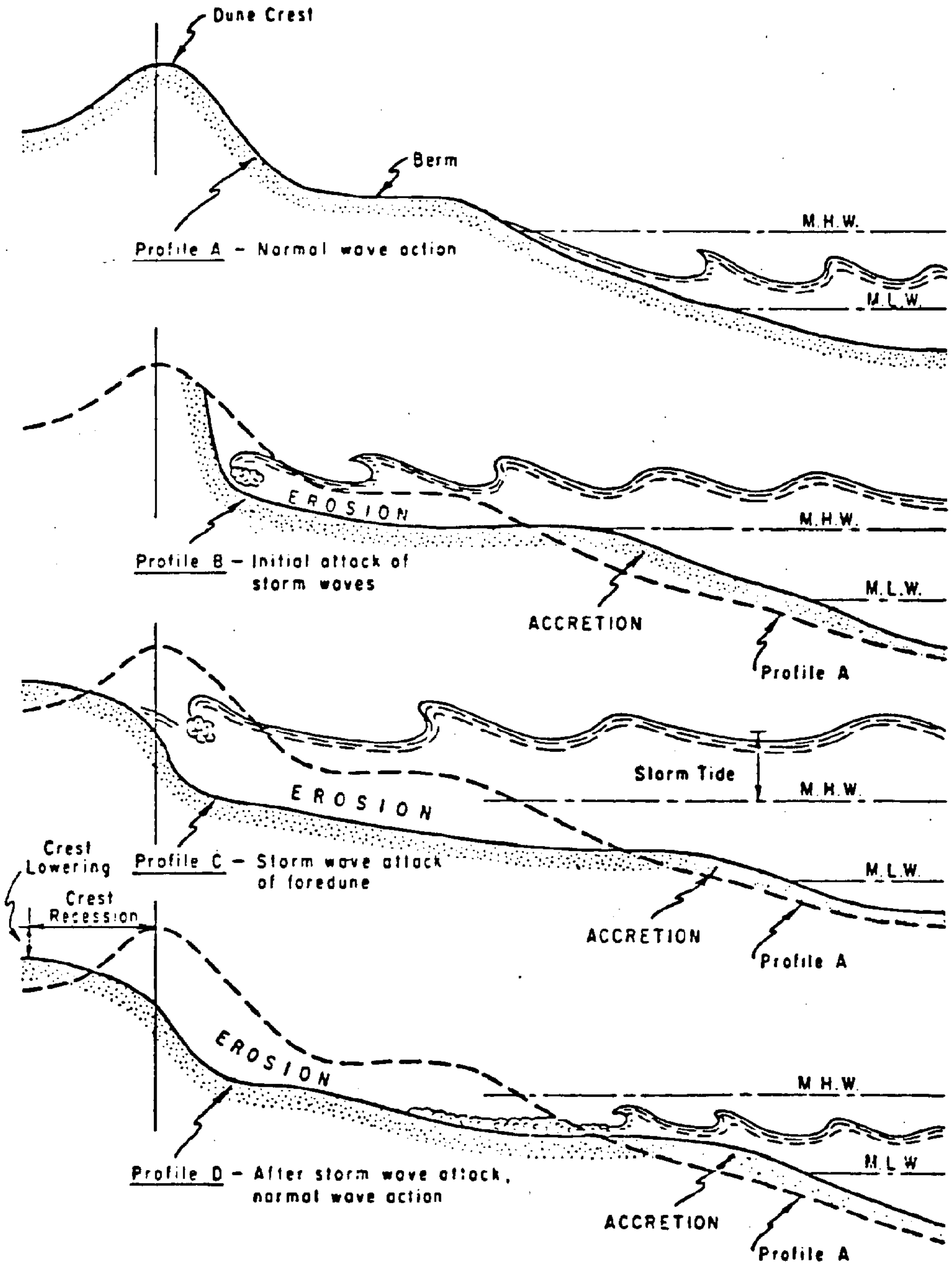

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Figure ~~8~~. Schematic diagram showing shoreline changes and sand movement under storm wave attack. (From U.S. Army Corps of Engineers, 1973).

If sand is removed from this dynamic system, then there will be an adjustment to the shoreline toward a new equilibrium. This adjustment would be through shoreline erosion, foredune erosion, and/or reduction in the volume of offshore sand.

Winds blowing across the beach move sand in a series of hops and bounds. This method of particle movement in air (and water) is known as saltation. The typical northwest and southwest winds carry sand from the foreshore to the backshore and from the backshore on to the foredune. Sand that is blown into the creeks can be carried back into the ocean. Wind transportation of sand is an important part of the natural repair of foredunes eroded by storm waves.

During periods without storm waves and particularly during the summer, the sand in bars is moved inland by relatively gentle waves and swells on to the beach where it develops a wider beach and a berm (see Figures 5 and 10). The widened beach renews protection for the foredune and upland from wave action and provides a wider area for wind transportation of sand.

Substantial deposits of logs were found south of Spring Lake/Watseco Creek Outlet, at Spring Lake Outlet and slightly south of Crescent Lake Outlet. Old aerial photos indicate that driftwood deposits have been common features at the creek outlets and near the jetties over at least the last 46 years. The photos also indicate logs behind the foredune after major storm events. Drift logs are also exposed in eroded foredunes.

Aerial photos taken April 28, 1939, after a large storm in January, show driftwood in almost all the creek outlets, where it was wedged into the narrow landward part of the outlet areas. The 1939 photos also show that the largest concentrations of drift logs are near the mouth of Nehalem and Tillamook Bays, the drift logs are mostly on low lying land accreted as a result of jetty construction, and a large number of drift logs had been tossed or floated over the then low foredunes. Aerial photos taken in 1964 show a substantial volume of driftwood near Crescent Lake outlet on both the north and south. Photos taken in 1966 show the logs near Crescent Lake outlet and another large driftwood deposit in an area slightly north of Saltair Creek. Some of these logs were apparently tossed inland onto Highway 101 in a storm in December 1967.

Natural deposits of drift logs that accumulate at the mouth of streams have a positive value in protecting against ocean erosion. The accumulation acts as an extension of the foredune in reducing the velocity and impact of breaking waves in large storm/high tide events. In an undeveloped area, these are qualities worthy of protection.

In developed areas the accumulations of drift logs at the mouth of streams can have negative values. Fresh and marine flood waters drain from areas east of the logs at a slower rate than through a clear channel. Outflow past the logs can cause local scouring of stream banks. Driftwood at the creeks can be moved by storm waves and freak waves to inland areas, damaging houses and blocking the highway and railroad.

Driftwood removal has been occurring where accumulations build up at the stream outlets, except at Spring Lake Outlet. Removal in other beach and foredune areas is occurring but currently appears to be only at a low level. A higher level of removal is not feasible because of the sparse distribution of driftwood, except in the Watseco Creek area.

There are presently no massive accumulations of driftwood at the base of the foredune in the study area, but there is a large accumulation at Watseco Creek in a former creek channel. The following narrative is provided in anticipation of future accumulations and in regard to the accumulation near Watseco Creek.

Driftwood deposits on the backshore can either be a benefit or destructive force to the foredune. Massive driftwood deposits that interlock provide excellent wave protection by breaking up wave energy before it reaches the foredune. They also collect wind-blown sand and can be the start of new foredunes. Backshore deposits known to the study team on other beaches are sometimes 50 to one 100 feet wide and a mile long. They tend to create a false security for oceanfront proterty owners.

At Kla-he-nee Shores, north of Florence, Oregon, during the El Nino waves of winter 1982-83, the entire driftwood mass floated off the beach in less than three days. Wave erosion was severe and emergency riprap was permitted on

2,200 feet of oceanfront. This same area had been stable for twenty years due to the wave protection afforded by the driftwood deposit. The same protection was afforded the sand bluffs north of Siletz Bay from the bay to the Inn at Spanish Head until beach logging was allowed in 1976. Severe wave erosion followed the log removal, again resulting in emergency riprap installation.

The partial removal of wood from interlocked deposits loosens the mass. Loose logs and stumps act as battering rams, increasing erosion of the foredune and increasing inland structural damage. It appears that massive accumulations in backshore areas need to be evaluated and either removed during summer or left intact.

Driftwood should not be removed when it accumulates in an eroded portion of a foredune because it aids the natural repair of the foredune.

The accumulation of drift logs near Watseco Creek are not well interlocked and could be pushed or floated further inland where they could block Watseco Creek. As a result, Watseco could move south and possibly endanger existing development. However, the logs are now occupying a gap in the foredune and will probably increase the rate of repair of the foredune. The logs at Watseco Creek could also be washed out and transported to other shoreline or stream mouth areas. It is our opinion that the logs in the former foredune area should remain to aid in the rebuilding of the foredune.

FOREDUNE PROCESSES

> "Previous to the introduction of European beachgrass in Oregon in the late 1800's, the active foredune on most shorelines was absent or was a relatively low, discontinuous ridge composed mostly of remote to closely spaced mounds. After European beachgrass colonized the foredune, the increased deposition of sand elevated the ridge first as isolated hummocks that coalesced and resulted in a relatively continuous ridge." (U.S. Department of Agriculture, Soil Conservation Service, 1975)

On much of the study area shoreline, an active foredune occurs on the east side of the beach. The foredune is susceptible to ocean flooding, ocean erosion, battering by wave carried logs, and wind erosion and deposition. To a limited extent, the foredune is capable of acting like a dike against ocean flooding and is capable of dissipating wave energy through erosion of the stored sand. However, ocean flooding is still a hazard where the foredune is low in elevation and thin enough to be breached by erosion. High waves can erode through or overtop a foredune. The foredune with European beachgrass reduces the sand transporting capacity of wind. This results in deposition of sand on the foredune instead of on inland areas. The beachgrass and other foredune vegetation also reduces the capacity of wind to transport sand off of the foredune (wind erosion). The protective capability of the beach-foredune system is enhanced by retaining sand in the foredune.

> "Dunes are the final protection line against the sea, and are also a savings bank for the storage of sand against a stormy day.
>
> "And stormy days do come. Strong winds blow high waves

before them. These waves are so huge that the nearshore slope weakens them only slightly. The thrust of the wind and the waves toward the shore raises the elevation of the sea and large waves pass over an offshore bar without breaking. If the storm occurs at high tide, the storm surge and the tide superelevate the waves and some of them may break high on the beach or even at the base of the dunes. After a storm or stormy season, the natural defenses are again reformed by normal wave and wind action." (U.S. Army Corps of Engineers, 1971, page 7)

Snapshots dating in the early 1900's (Walker, 1983) indicate that there was little or no active foredune formation at that time in the central portion of the study area. It is reasonable to assume that without a hardy beachgrass and with repeated wave erosion, the only active foredunes were isolated hummocks that developed on the accreted lands adjacent to the jetties and on backshore portions of the beach. Much of the central shoreline appears in old photos as a broad, gently sloping beach leading inland to a relatively well vegetated stable dune ridge. This dune is classified as a younger stabilized dune by the U.S.D.A. Soil Conservation Service (1975). Remnants of this stable foredune remain in the study area to the east of the 1939 shoreline mapped from aerial photographs in this report (Technical Report Map). Remnants of the old foredune are generally absent near the creek outlets. The highest elevations on the old foredune are in the Lake Lytle area, and the highest elevation there is 43 feet. The mature vegetation and height of the old foredune indicates that much of the shoreline had been stable for at least 50 years. The construction of the jetties and the introduction of European beachgrass altered that condition.

The date of the introduction of European beachgrass in the Nedonna/Rockaway area was not determined during this investigation. Some residents and publications identify the 1930's as the probable time. Aerial photos from 1939 indicate that the beachgrass was present at that time. Newly accreted land near the jetties had a low, hummocky, active foredune in 1939. The aerial photos were taken 3 or 4 months after a severe storm. This early predecessor of today's active foredune had been severely eroded, breached and overtopped by storm waves.

The foredune continued to increase in height and width after the introduction of European beachgrass. The growth has been episodic because of both local and wide-spread wave erosion. Repeated episodes of erosion in some locations has produced one or more remnant foredune ridges east of the present foredune. These remnant ridges are evidence of the episodic nature of accretion on this shoreline following the introduction of European beachgrass. Repeated erosion and a limited supply of wind-blown sand has resulted in poor foredune development near stream outlets throughout the history of active foredune development.

Variations in ocean erosion, wind deposition, and grading has resulted in a complex and somewhat irregular active foredune. The foredune is illustrated on the Technical Report Map. Figure 12 is a generalized cross section of a foredune. The unstable creek outlet areas are

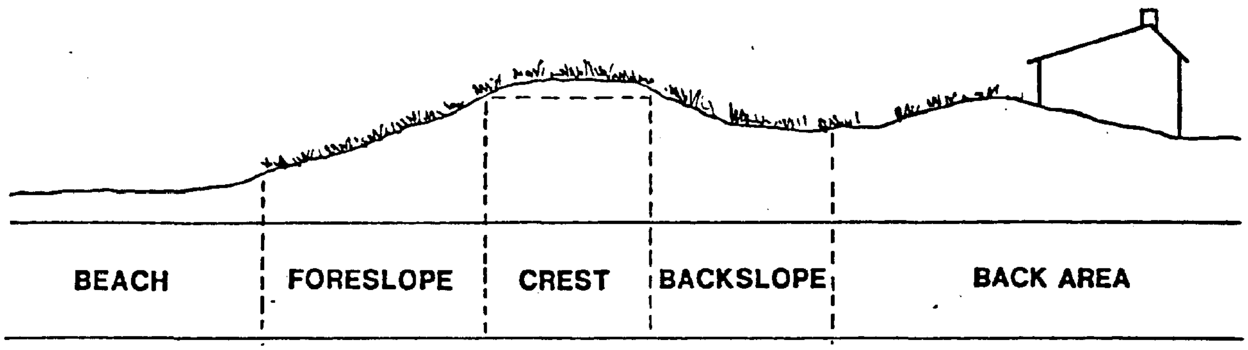

Figure 12. Typical foredune cross section and classification of features.

treated separately.

The foreslope is the seaward side of the foredune. Most foreslopes in the study area show evidence of past erosion. Erosion in the past one or two years has left a nearly vertical foreslope in some locations. After erosion of the foreslope, wind transported sand, driftwood and European beachgrass combine to repair the damage to the foredune. At first the repaired foreslope has an uneven surface and an uneven distribution of beachgrass. With more sand deposition the foreslope eventually develops a relatively even slope and coverage of beachgrass. Depending on the amount of foreslope erosion, it can take two to over five years for the foreslope repair to occur. Of course, further erosion can take place before repair can be completed.

The foredune crest is the top of the foredune. The shape, width and height of the crest, like the foreslope, is dependent mostly on the past erosion history or the amount of grading. Wave erosion can extend in to the crest or, in extreme cases, all the way through the crest. Wind transported sand and European beachgrass repair the erosion damage over several years, similar to the natural repair of foreslope damage. As a result, the crest varies in the study area from very thin, low and irregular to broad, high and relatively smooth.

The backslope is inland of the crest. It is relatively smooth and evenly sloped where there are lowlands inland from the foredune, such as in the Nedonna Beach area. In other areas backed by an older, stable foredune, such as the Lake Lytle oceanfront area, continuous accretion and episodic erosion has resulted in a condition where there is almost no backslope. What backslope exists merges in a short distance in to the back area.

The back area referred to in this study refers to the conditionally stable and stable sand areas inland from the foredune backslope. In the Nedonna Beach, Saltair Creek, and Watseco Creek areas the back area is low lying land. In the rest of the study area, the back area is composed of remnants of older foredunes and stable dune ridges.

The protective capability of the foredune is primarily a function of its bulk (height and width). The height is protection from flooding and its overall bulk is protection from eortion. European beachgrass is integral to the protective ability of the foredune. The beachgrass helps to build a high foredune and the roots bind the sand, thereby increasing resistance to wind and wave erosion. A gently sloping foreslope is also protective in that the energy of wave runup can be dissipated with a minimum amount of erosion.

At this time there is no known optimum dune bulk. In developed areas the optimum hiehgt is logically that elevation necessary to adequately protect inland areas from probable levels of ocean flooding. In regards to width, the wider the better because in a wide foredune there is more sand in storage available to be eroded. In regard to the slope of the foreslope, the rule is the flatter the better, but European beachgrass traps sand and builds up so rapidly that maintining a low slope is unrealistic. A foreslope of 1:4 to 1:3 (25% to 33%) is reasonably realistic and is the range of managed foredune foreslopes in Europe.

FLOODING

Two type of flooding occur in the Rockaway/Nedonna area -- fresh water and ocean flooding. Fresh-water flooding is not a direct subject of this study, but driftwood and sand block stream outlets and aggravates inland flooding. Ocean flooding occurs when high tides combine with large storm surges and/or large waves. Past ocean flooding has not been as extensive as the flooding projected for the 100-year flood (U.S. Department of Housing and Urban Development, 1978).

A comprehensive documentation of past ocean flooding in the study area, as well as the rest of the Oregon Coast, was compiled by Stembridge (1975) using newspaper accounts. It was not possible or necessary within the limitations of the Rockaway/Nedonna study to review newspaper reports specific to the study area. The information from Stembridge has been examined for specific information on the study area and was combined with information provided by Schlicker and others (1972), information from the tabloid (Memories of Rockaway, Oregon) compiled by Rosemary Walker (1983), and from information provided by residents. Table ~~1~~ 3 provides the information compiled from these sources.

The U.S. Department of Housing and Urban Development (HUD) (1978) and Federal Emergency Management Agency (FEMA) (1982) have conducted studies and prepared maps of coastal flooding for use in establishing flood hazard areas and flood insurance rates. This is the only mapping of coastal flooding for the study area. The regulatory flood is the 100-year

Table ~~2~~ 3. Damaging Events Affecting the Rockaway/Nedonna Area

Feb. 1911	Breakers and drift logs over railroad.
Jan. 1914	
Dec. 1931	Local flooding and logs tossed on Hwy. 101.
Oct. 1934	Local flooding and logs tossed on Hwy. 101.
Dec. 1935	Local flooding and logs tossed on Hwy. 101.
Jan. 1939	Local flooding and wave tossed log damage to houses at Twin Rocks and Manhattan Beach. Recurrence interval of 75 years.
Dec. 1940	
Oct. 1941	
Nov. 1948	Local flooding and logs tossed inland
Jan. 1953	Local flooding and logs tossed inland. Shoreline erosion at Nedonna Beach.
Apr. 1958	Local flooding and logs tossed inland.
Jan. 1960	Local flooding and logs tossed inland.
Feb. 1960	Local flooding and logs tossed inland.
Oct. 1960	Freak wave damaging houses at Saltair Creek and tossing logs across Highway 101.
Spring 1962	Shoreline erosion at Rock Creek
Dec. 1967	Local flooding and logs tossed over foredune at N~~a~~edonna Beach, and Manhattan Beach; logs tossed on Highway 101 at Rock Creek and Saltair Creek.
Dec. 1972	Shoreline erosion.
Dec. 1974	Logs tossed inland.
Feb. 1976	Logs tossed inland. Recurrence interval of 10-15 years.
Oct. 1977	Shoreline erosion.
Feb. 1978	Shoreline erosion.
Winter 82/83	Shoreline erosion.

flood, a hypothetical flood with a statistical recurrence interval of once every 100 years (1% chance of occurrence in any year). The mapping (reproduced on the Technical Report Map) shows several classes of flooding. Of primary interest in this study is the velocity flood area (area subject to wave action) and the base flood elevations. In inland areas, the base flood elevations or depth of flood waters is illustrated as well as the extent of areas prone to flooding. Flooding extends inland beyond the limit of the map. See the flood mapping previously cited for more information.

The flood mapping is based on numerous hydrologic and hydraulic factors. Consideration was given to tides, storm surge, wave action, swell, offshore water depth, effective beach slope, and other factors (U.S. Department of Housing & Urban Development, 1978). Changes in offshore depth and changes on the beach and foredune following the mapping were not considered (Green, personal communication). In fact, it is those variations in offshore and onshore conditions that result in the differences in base flood elevation from one shoreline reach to another shown on the Technical Report Map.

> "On the open coast, effective beach slope and storm wave breaking height may vary dramatically in a relatively short distance along the shoreline. Therefore, two adjacent reaches may have 100-year flood elevations that differ by more than 1 foot." (U.S. Department of Housing and Urban Development, 1978)

The accuracy of the ocean flood hazard mapping is dependent on how much change occurs over time. In the study area, there have been changes in foredune width and height and beach width and slope since the flood studies. Further changes will occur through shoreline erosion, recovery from the recent El Nino, and possibly from natural changes in the offshore water depths (including seasonal changes).

The Technical Report Map illustration of flood zones was reproduced from HUD and FEMA flood insurance rate maps. The original maps are at a scale of 1 inch = 1000 feet and 1 inch = 600 feet. The information was transferred as accurately as possible to the working map scale of 1 inch = 100 feet.

An attempt was made to improve on this mapping by transferring the base flood elevation to the working map using the much more accurate topography on that map. This approach was found to be confusing by many persons involved in this investigation. That information has been removed from the maps, but the elevation in feet above mean lower low water is shown for the base flood.

The regulatory flood insurance mapping supercedes natural and man-made changes in the elevation and configuration of the land. Unfortunately this leaves a small but significant discrepancy between the regulatory flood and the real factors controlling shoreline flooding. This is one of the reasons why foredune grading, allowable under Goal 18 of the Statewide Planning Goals and Guildlines, is limited to an elevation of 4 feet above the base flood elevation. The extra 4 feet is necessary to accommodate the constantly changing nature of the shoreline and the inflexible nature of flood plain regulation.

SHORELINE EROSION AND ACCRETION

There is very little documentation of shoreline erosion in the study area. The Oregon Department of Transportation has a file on the 1977-78 erosion at Nedonna Beach. Schlicker and others noted erosion near Watseco Creek in 1971-72. A publication by Terich and Komar (1974) on the erosion at Bayocean Spit included a diagram that inferred that erosion occurred in the study area as a result of the construction of the north jetty at Tillamook Bay. Erosion of much of the foredune in the southern half of the study area was noted in a study of the beaches and dunes of Oregon (U.S.D.A. Soil Conservation Service and Oregon Coastal Conservation and Development Commission, 1975).Further information on shoreline erosion has been obtained by field investigation, aerial photo interpretation, and information supplied by residents and County Planning Department staff.

The lack of published documentation is apparently the result of the small amount of structural damage in the study area that has been caused directly by erosion. There has been severe local erosion, primarily near the stream outlets and near the jetties. Erosion by rip currents preceding storm surges and large waves has increased flood damage in some locations. Examples of erosion events are presented but do not represent all of the erosion that has occurred in the recent past.

It appears that foredune erosion in the study area is similar to erosion events on other portions of the Oregon

Coast. In the following quote Komar (1979) discusses the erosion that took place on the Siletz spit in the 1950's, early 1960's and in the winters of 1972-1973, 1975-1976, and 1977-1978.

> "In each instance foredune erosion did not occur over the entire length of the spit. Instead, it was limited to two or three zones, each some 200 feet of spit length. This localization of dune erosion was governed by the positions of rip currents as ...
>
> "In summary, erosion of foredune areas can be very rapid, removing some 100 feet of property in two or three weeks. The erosion is mainly centered in the lee of rip currents which hollow out embayments into the beach. Maximum erosion occurs under large storm waves, and is also aided by the high water levels of spring tides. Following erosion the foredunes may be re-established by beach sand washing and blowing into the eroded zone; drift logs aid in dune reformation by trapping the wind-blown sand." (Komar, 1979)

There is also little information on shoreline accretion in the study area. Accretion on the shoreline south of the Nehalem jetties was briefly acknowledged by the Corps (U.S. Army Corps of Engineers, 1980). There are several reports that refer to the accretion north of the Tillamook jetties (Lizarraga-Arciniega and Komar, 1975; Komar and others, 1976a; and Komar, 1978). Cooper (1958) identified the study area as progradational and noted widening of the beach possibly as a result of construction of the north jetty at Tillamook Bay. Dicken (1961) notes progradation at several points in the study area determined from comparison of aerial photographs taken in 1939 and 1960. Stembridge (1975) maps the shoreline as prograding and notes that the least accretion was 30 feet between 1939 and his investigation.

The shoreline and accretion in the study area that has been documented in this investigation is illustrated on the Technical Report Map and described in the descriptions of each of the management units and stream areas in the study area. Supposedly, accretion in the study area of the ocean shoreline could be attributed to: 1) lowering of sea level, 2) increased sand supply, 3) construction of jetties, or 4) introduction of European beachgrass. The ultimate cause of shoreline accretion in the study area is not known, but it is probably because of the introduction of the jetties and the introduction of European beachgrass.

WIND EROSION AND DEPOSITION

Wind erosion does not have a severe impact at this time. Minor scouring of poorly vegetated foredune areas is occurring in all management units. This tends to perpetuate uneven foredune growth, but it does not present a direct threat to inland properties. Wavecut escarpments in the foredune are experiencing wind erosion, but this tends to deposit sand at the base of the escarpment and promote repair of the foredune foreslope.

The current practice of uncontrolled foredune grading now occurring in the Nedonna Beach and other sections is causing minor wind erosion because of the exposure of sand unprotected by beachgrass. Due to the shallow depths and direction of the present grading cuts (east-west), most wind-blown sand deposits are small and occur on the easterly portions of the same lot. The beachgrass in the newly graded areas generally recovers quickly because the excavations are shallow. Vegetation on adjoining lots has also prevented major wind erosion problems.

CREEK OUTLET PROCESSES AND FEATURES

Shoreline processes at creek outlets are apparently poorly understood. No published information was found in our research. This section of the report presents conceptual information on shoreline processes analyzed in respect to the observed features at creek outlets in the study area. The format used here is to first describe the observed features, second describe the potential processes, and third to attempt to analyze the causes of the observed features.

Figure __ illustrates the typical features found at creek mouths in the study area. The northern and southern limits of the area of creek influence was determined from the inland curvature of the shoreline. Because the shoreline at the creek areas has changed more radically over time than the foredune areas (see Figures __, __, __, and __), the area of creek influence was determined from historical shorelines, as well as the present shoreline. Former shorelines were mapped from historic aerial photos dating back to 1939. In some cases the shoreline is further inland than in 1939, but in most cases the shoreline is further seaward than in 1939. In the latter situation the area between the former shoreline and the present shoreline is an area of dune hummocks, active wind erosion and driftwood.

The present shoreline near the creeks is backed by a low, thin, poorly developed foredune or nor foredune at all. The presence of emerging foredune ridges near creek outlets appears to be related to a recent history of shoreline accretion, and shorelines recently subject to erosion have little or no developing foredune.

Observations made during this study (April 1985 to February 1986) indicates that wind and wave deposition of sand in the creek outlet areas occurs during periods of calm seas and low creek flow. Erosion occurs during periods of storm waves and high stream runoff. Erosion appears to typically leave a beach excarpment or berm of a few inches to several feet in height on the beach. In some cases the erosion extended to the vegetated shoreline and in to the poorly developed foredune or to previously placed revetment. The erosion appears in most cases to be caused by ocean waves, but in one creek area (Spring Lake outlet) there was testimony by one resident that the combined flow of Spring Lake outlet and Watseco Creek caused shoreline rosion on the north side of the area of creek influence. This occurred during the recent El Nino when there was a net northerly littoral transport of sand that might have pushed the creek flow northward against the former shoreline. The configuration of shorelines at Rock Creek and Crescent Lake outlet indicate that stream erosion might have contributed to shoreline retreat.

Review of historic aerial photos indicates that the creeks migrate within the area of creek influence. It is logical that channel migration would occur as a result of fluctuations in the creek flow and deposition of sand by waves, littoral transport and wind transport. Migrating channels are characteristic of streams and rivers on deltas and at their months where not controlled by jetties. Two recent riverine examples are the mouth of the Necanicum River at Seaside and the mouth of the Alsea River at Waldport. In both of these situations shoreline erosion was related to shifts in channel locations.

A stream delta was found to occur at all of the stream outlets on aerial photos and in field investigation at low tide. The delta is illustrated on Figure __ by the westerly bulge in the low tide line. It is reasonable to assume that these deltas form from stream transported sand. It is also reasonable to assume that the deltas are constantly changing in form and volume in response to stream flow, stream location, littoral drift, ocean erosion, and wave deposition of sand. It is not known how much these deltas block or alter littoral transport.

JETTIES

The Nehalem Bay jetties on the north and the Tillamook Bay jetties on the south have had a profound effect on beaches and dunes in the study area. Jetties are placed to stabilize a river mouth at a particular location as it enters the ocean. Without jetties, river mouths tend to migrate in response to littoral movement of sand and offshore sandbars, as well as in response to river flow, and river sediment load, and changes in channel location in the estuary.

Extensive studies of the effect of jetties on shorelines along the Oregon Coast have been done by Dr. Paul Komar of Oregon State University: Komar describes the process as follows:

> "It is seen that where two jetties are constructed, there is beach sand accumulation both to the north and south, immediately adjacent to the jetties. This deposition and shoreline advance occurs because an embayment is formed between the newly constructed jetty and the pre-jetty shoreline. Before jetty construction, the shoreline curved inward toward the inlet and was in equilibrium with both the ocean waves and with the currents coming in and out of the inlet. Jetty construction eliminated the inlet currents acting on that curved portion of shoreline, leaving only the waves. The waves broke at angles to the curved shoreline and so moved sand into the embayment until it completely filled with sand (Figure __). Once the embayment filled and there was a smooth and nearly straight shoreline parallel to the dominant waves, then a zero net littoral drift once again prevailed. After this stage is reached there are no additional large-scale adjustments of the shoreline due to the presence of the jetties. There a new equilibrium is achieved, and shoreline changes do not continue indefinitely." (Komar, 1979, pp. 25-26)

In fact, Nedonna Beach is such a filled embayment. Prior to construction of the Nehalem jetties the Nedonna Beach area was part of the river mouth and curved shoreline re-entrant.

> "The sand that fills the shoreline embayments produced by jetty construction must come from somewhere, and most of it comes from shoreline erosion at greater distances from the jetties. Thus a symmetrical pattern of erosion and deposition results with beach sand accumulation immediately adjacent to the jetties, both to the north and south, and with erosion at greater distances from the jetties." (Komar, 1979, pp. 26)

> "The amount of shoreline retreat produced by jetty construction in areas, such as the Oregon coast where there is a zero net littoral drift, is a function of the size of the embayment to be filled adjacent to the jetty and the length of beach over which erosion occurs to supply the sand." (Komar, 1979, pp. 27)

"The shoreline affected by the Tillamook and Nehalem jetties appear to be at or near equilibrium. However, Bayocean Spit experienced dramatic erosion following jetty construction and up to 1952 when the spit was breached. Now that the embayment at the jetty has filled it is reasonable to conclude that little, if any, jetty-induced erosion will occur. Komar further notes that once this equilibrium is established jetties can subsequently be extended without producing additional major shoreline readjustments and erosion." (Komar, 1979, pp. 28)

"The filled embayment areas to either side of inlet jetties are dependent upon the presence of the jetties. If the jetties are allowed to degrade than there may be some erosion of filled areas. Prior to rehabilitation in 1980-81, the Nehalem jetties deteriorated to the point that they were covered with water at high tide. The shoreline at this time curved back inward into the inlet but not as much as prior to jetty construction meaning that without rehabilitation further erosion might have been expected." (Komar, 1979, pp. 28)

Reconstruction of the Nehalem jetties was completed in the fall of 1982. The rehabilitated jetties have, in concert with the 1982-83 El Nino, resulted in substantial accretion of the beach at the south jetty. Approximately 200 feet of beach widening occurred in some locations from October 1978 to January 1984.

The jetties were rehabilitated to standards superior to the original construction according to Tom Clapper and Harold Herndon of the U.S. Army Corps of Engineers (personal communications, 1986). The large, outer armoring stores were carefully placed rather than randomly end-dumped and a core of smaller store was placed. The jetties have an economic life expectancy of 50 years, but maintenance will be required in 15 to 20 years (1997 to 2002).

Because there is no absolute assurance of maintenance of the jetties or of the projected life expectancy, it is recommended that no new development be allowed on lands at the north end of Nedonna Beach between the existing foredune and the jetty, the condition of the jetties be monitored and newly accreted lands adjacent to the south jetty should be developed because of the possibility of future erosion and flooding as the jetties deteriorate.

FOREDUNE MANAGEMENT UNIT DESCRIPTIONS AND RECOMMENDATIONS

The shoreline of the study area has been divided into fore foredune management units (See the Technical Report Map). From the north to south, the units are:

1) Nedonna Beach - extending from the south jetty at Nehalem Bay to Crescent Lake outlet,

2) Lake Lytie Oceanfront - extending from Crescent Lake outlet to Rock Creek,

3) Rockaway Beach - extending from Rock Creek to Saltair Creek, and

4) Rockaway South/Twin Rocks Beach - extending from Saltair Creek to Spring Lake Outlet/Watseco Creek.

The shoreline was divided into these four landscape/management units based on an analysis of the physical characteristics of the components of the shoreline (beach, foredune and upland area). This analysis confirmed our initial impression. Each shoreline between the creek mouths in the study area has consistent landscape characteristics. However, it was the condition of the foredune on the westerly facing shoreline and at the creek mouth areas that necessitated the management unit divisions. The physical processes and characteristics at the creek mouths have produced a foredune that curves inland compared to the rest of the shoreline and the foredune is poorly established or nearly non-existent at the creeks.

The following is a description of the foredune management units and recomendation for foredune management. Descriptions and recommendations for creek outlet areas follow the section on management units.

NEDONNA BEACH MANAGEMENT UNIT

General

This management unit extends from the recently rehabilitated south jetty at Nehalem Bay to the area of influence of the stream outlet of Crescent Lake, a shoreline distance of about 5900 feet. (See the Techncial Report Map.)

The north end of Nedonna Beach is similar to stream outlet areas in having a foredune that curves inland, but this area is not treated separately as are the creek outlets. This is because experience at other jetties indicates that the area will develop a new foredune west of and connected to the existing foredune as a result of rehabilitation of the Nehalem jetties. Treatment of this area as a foredune is desirable at this time to promote inland protection from ocean flooding and erosion. If the jetty is allowed to deteriorate, then the area would need to be managed like the unstable stream outlet areas.

This foredune unit begins on the north on land that accreted to the shoreline after the construction of the Nehalem jetties. The south jetty was completed in 1915 (U.S.

Army Corps of Engineers, 1980). The westerly extension of shoreline adjacent to some jetties on the Oregon Coast have been documented by Lizarraga-Arciniega and Komar (1975) and summarized by Komar and others (1976a) and Komar (1978). The initial accretion occurred rapidly following jetty construction in 1915 until about 1920, but deterioration of the jetties reversed the trend to one of shoreline erosion. Erosion has occurred in this area but cycles of erosion and foredune repair has resulted in a roughly stable, slowly accreting shoreline with a foredune that is only 50 to 70 feet wide at some points. Recent rehabilitation of the Nehalem jetties has resulted in increased accretion near the jetties that will probably continue for several years and will probably result in a new foredune west of the present foredune.

The middle portion of the Nedonna Beach area has been subjected to less ocean erosion and more wind-blown sand deposition compared to the northern portion. As a result, the foredune locally over 200 feet in width and up to 32 feet in hieght. There are also remnants of an older foredune about 70 feet east of the present foredune. This slow accretion does not mean that the area is free from future ocean erosion. In 1977-78, this beach was subjected to substantial erosion of the foredune.

In the southern portion of Nedonna Beach, the foredune is 22 to 28 feet in elevation. The height decreases toward Crescent Lake outlet on the south. Adjacent to the Manhattan

Beach State Wayside, the present foredune is backed on the east by an older, stable dune that is less than 26 feet in elevation.

Vegetation

The vegetation line has been moving seaward on the foreslope of this accreting beach. The dominant specie is European beachgrass which is in a vigorous state of growth because of wind-blown sand deposition. There is less than 5% sea lyme-grass. It is showing the same vigorous growth but it is currently providing no competition for the European beachgrass. American sea rocket is growing sparingly at the winter high tide line. However, its unburied condition indicates a very mild spring and early summer this year (1985) with little eolian (wind blown) sand deposition from prevailing northwest winds. The foreslope is the forward slope of a very irregular foredune. Large voids in the vegetative cover cause severe hummocking that then result in wind scour. West of the active foredune crest is a newly forming foredune characterized by hummocks occupied primarily by European beachgrass. Note: See Appendix __ for more information on foredune vegetation.

The average width of the crest of the current active foredune is shown on the Technical Report Map. For the purpose of this study, the mapped lines of the crest of the foredune are only average. Mapping of all of the small variations would not be feasible and would not be useful for purposes of the management plan. One winter's southwest winds and waves would alter the small variations. On the crest, the dominant species is European beachgrass in a vigorous state of growth due to sand deposition from the beach. Sea lyme-grass in small patches is holding its own and is scattered throughout the crest area. In the central portion of this management area the sea lyme-grass (a secondary dune species) appears to be left over from the early foredune that formed after the initial construction of the south jetty at the mouth of the Nehalem River. Beach pea, another secondary species, is present in the southern two-thirds of this management unit. Again, this is an indication of a foredune backslope species that is still surviving on a new foredune crest. This current crest is part of a natural erosion repair process by eolian deposits of sand from the beach. The result is this mix of initial (or pioneer) and secondary species. In addition, there is a scattering of large headed sedge, indicating the lessening sand supply caused by the formation of the new foredune out front. Grading (excavating) of the foredune crest has occurred in this area, but there is no evidence of substantial adverse impacts to the vegetative cover or as a result of sand blown from the graded areas. This is because the majority of grading has not totally removed or destroyed the roots of the beachgrass and the grass has recovered.

On the backslope of the Nedonna Beach foredune, vigorous stands of European beachgrass still dominate. The upper half of this backslope is locally either European beachgrass or lyme-grass with evidence of fertilization from eolian beach sand deposition. Again, this stand is complemented by large areas of beach pea. Graded areas have vigorous stands of European beachgrass from recovery of old roots. The beachgrass is of varying height and density, depending on time of year of grading. The grass has not recovered after grading only in two locations. Since they are both on the north end, it is possible that they were unvegetated weak spots before grading. However, herbicides may have been used. The lower two-thirds of the backslope in the Manhatten Beach Wayside area is a mix of old lyme-grass stands and scattered pockets of climax plants associated with dune areas cut off from the beach sand supply. For more information on plant species and plant succession on dunes, refer to Crook (1979) and Appendix __.

Flooding

The base flood elevation for the 100-year flood in this management unit is 22 feet. The foredune is over 32 feet in elevation at its highest. At the County parking lot at the north end of Nedonna Beach the foredune is about 18 to 19 feet in elevation at its lowest. Northeast of the parking lot the foredune curves inland and drops in elevation. The lowest foredune elevations are on the north and south ends of this management unit. Grading has reduced some portions of the foredune in elevation below the 22 foot base flood level. The only documented flooding in this unit occurred at the County parking lot in 19__.

Erosion

This area accreted rapidly after the construction of the jetties and apparently by 1938 had developed a low foredune. A very severe storm in January 1939 eroded an unknown width of the west side of the foredune and breached and overtopped the foredune locally. In January 1953, there was shoreline erosion at Nedonna Beach but the extent is unknown. In the winter of 1977-78, a rip current embayment resulted in erosion on the northern end of Nedonna Beach. The shoreline recession appears to have been about 100 feet. This erosion threatened many homes and emergency riprap was placed to reduce further erosion. The riprap is illustrated on the Technical Report Map, but it is now almost completely under sand that has healed the washout of the foredune. There was windspread shoreline erosion at the same time in Nedonna Beach south of the rip current (see the 1970 and 1977 shorelines on the Technical Report Map), but the overall erosion did not exceed 10 to 20 feet. The entire shoreline has had minor erosion (in the tens of feet), but overall there has been slow net accretion since 1939 on the shoreline.

Accretion

After construction of the south jetty at Nehalem Bay in 1915, there was rapid accretion in the northern portion of this unit. There are no records of the amount of accretion, but 1939 aerial photos indicate 1,200 feet or more of accretion occurred. According to the U.S. Army Corps of

Engineers (1980), the shoreline "built out rapidly until about 1920, then began receding..." From 1915 to 1920 that is 240 feet per year or more. The shoreline recession was caused by the deterioration of the Nehalem jetties. Rehabilitation of the jetties was completed in the fall of 1982. Accretion is now occurring near the south jetty. Aerial photography indicates that there has been beach accretion of 150 feet or more from 1978 to 1984, but the accretion might be partially a result of the net northerly littoral drift produced by the recent El Nino.

The northern portion of this management unit has had net accretion of up to 100 feet from 1939 to 1984 (an average of about 2.2 feet per year). From 1939 to 1964, the shoreline had accretion of up to about 100 feet. The extent of intervening erosion during that time is not known. From 1964 to 1970 there was up to 80 feet of accretion. From 1970 to 1984 there was erosion caused shoreline retreat of up to 80 feet.

The central and southern portion of this unit had net accretion of up to about 120 feet from 1939 to 1964. From 1964 to 1970 there was a maximum of about 40 feet of accretion. From 1970 to 1984 the shoreline remained somewhat stable with local erosion and accretion of a few feet. For the peiod from 1939 to 1984 there was average accretion of about 3.6 feet per year.

Present and Future Foredune Stability

The foredune at Nedonna Beach has generally demonstrated in stability since at least 1939 and can be expected to be at least equally unstable for a similar or larger period into the future. From the completion of the south jetty in 1915 until about 1920 there was rapid accretion in the Nedonna Beach area. The accretion was followed by an unknown total amount of erosion resulting from the deterioration of the jetties. The Corps of Engineers estimates an average of 5 feet per year. The aerial photos of 1939 are the earliest, accurate information available on the shoreline in Nedonna Beach. From 1939 to the present there has been slow accretion of the shoreline and growth of the foredune interrupted by episodes of erosion.

There are documented erosion events in 1939, 1953, and 1977-78. These erosion events indicate that shoreline and foredune erosion can be anticipated to be as great as 100 feet to 150 feet and to possibly breach the foredune locally. Erosion that has breached or nearly breached the foredune has been generally limited to 1000 feet or less of shoreline where a rip current embayment effectively concentrated the foredune erosion. In 1977-78 the foredune erosion was concentrated on about 2000 feet of shoreline by two rip current embayments. Widespread shoreline erosion has occurred, but it has not been as damaging to the the foredune and has not threatened homes.

Eroded areas of the foredune have been naturally repaired by wind and wave transported sand and then continued to slowly accrete at an average rate of about 3.6 feet per year from 1939 to 1984.

An increase in the rate of foredune accretion is expected to occur for several years following the rehabilitation of the Nehalem jetties. The rate of accretion will be greatest near the south jetty and smallest on the south end of the Nedonna Beach Management Unit. There is no precedent on which to estimate the rate or total extent of accretion. A new foredune will probably develop naturally to the west of the present foredune from the south jetty to about Riley Street. This new foredune will decrease the potential for ocean flood or erosion damage to existing development in the Nedonna Beach area until the Nehalem jetties deteriorate. If the jetties deteriorate the new foredune will be eroded and the shoreline might return to the condition previous to jetty rehabilitation, or there could be further shoreline erosion and shoreline retreat.

South of about Riley Street there may be a short term increase in the rate of accretion punctuated by episodes of erosion. This will then be followed by a return to the previous rate of slow accretion.

The south end of this management unit could experience short term shoreline retreat if this area is a source of sand for the new foredune near the jetty. There is no evidence of substantial shoreline erosion in this area following jetty construction, and there is a long shoreline area available to supply sand for the accretion. To minimize the amount of sand needed in the accretion area before an equilibrium condition is reached, it would be beneficial to promote foredune development in the accretion area by planting European beachgrass or possibly by using sand fencing. This would minimize the amount of sand blown inland behind the new foredune and effectively taken out of the sand supply-sand storage system.

Portions of the Nedonna Beach Management Unit have foredune crest heights in excess of that needed to protect development from 100 year flood elevation (26 feet as stipulated in Goal 18). There are also areas on the foredune crest that are below this minimum level. Sand excavated from crest areas above 26 feet elevation should be first used to fill in crest areas that are below the minimum height, thereby increasing the protective capability of the foredune in the event of a flood with a recurrence interval equal to or in excess of the regulatory 100-year flood. Foredune management in this area should also promote widening of the foredune to increase protection from ocean erosion. Widening of the foredune increases the amount of sand in storage in the foredune, the lands last line of defense against the ocean. The amount of widening that is practical is limited by existing development on the backslope of the foredune and by the easterly limit of the beach. Because there is no way to know how far westerly the foredune can be extended it would be best to use excess sand from the foredune crest to build up low and eroded segments of the foreslope and not use excess sand to extend the foredune westerly until the other priority fill areas are satisfied. Sand filling can occur where a new foredune is actively developing west of the existing foredune.

LAKE LYTLE OCEANFRONT MANAGEMENT UNIT

General

This section of shoreline is between the creek influence areas at Crescent Lake outlet and Rock Creek, a distance of about 6,800 feet. This is the longest, uninterrupted stretch of shoreline in the study area. Aerial photos from 1939 show substantial development along the shoreline. The photos also indicate damage to many structures in the storm of January 1939. The damaged homes had been built west of the older, stable dune that is east of Pacific Street. The Technical Report Map shows the shoreline after the storm but does not indicate the damage to inland areas from flooding and wave tossed logs. Since 1939 the shoreline has been slowly accreting, but there have been periods of erosion alternating with accretion. Apparently because of the alternating accretion and erosion, the foredune is poorly developed. The average foredune crest elevation is about 24 feet. The low and high points are approximately 18 feet and 28 feet in elevation on the active foredune crest. The base flood elevation ranges from 25 feet on the north, 26 feet and 27 feet in the middle of the unit, to 23 feet on the south end. Only a small area at the south end of the management unit exceeds the minimum elevation for grading. This unit is not suitable for dune grading. Dune management could increase the flood protection ability of the foredune.

Vegetation

Seaward foreslope growth appears to have been limited since at least 1939. While accretion is now taking place, field information and aerial photographs suggest continuing cycles of erosion and recovery. The dominant species is European beachgrass with about 30% to 50% coverage on the foreslope at this time. All beachgrass is in a state of vigorous growth due to deposition of sand from the beach. Because of the sparse grass cover, hummocks and wind scour troughs exist now and will continue creating an unstable foredune with low-lying weak spots. With minor surface grading, beachgrass planting of unvegetated areas, and a fertilizer maintenance program, this foreslope area could provide increased protection to inland development, though erosion will continue to occur periodically.

The crest section of the Lake Lytle Oceanfront foredune system is in a state of natural recovery from past erosion. The dominant species is European beachgrass showing vigorous growth due to sand deposition. The conditions here are similar to the foredune crest in the Nedonna Beach area. The crest area is uneven in height, and the vegetative cover is weak.

In this management unit, the backslope area is very short or indistinguishable from remnants of previous foredune crests. Vegetation consists mainly of old stands of European beachgrass with a mix of climax plants such as coast strawberry, seashore lupine, salal, and shore pine.

Flooding

The Technical Report Map shows the base flood elevations for portions of this management unit and the inland extent of the 100-year coastal flood with velocity (wave action). Inland of the velocity flood zone the map shows areas that would experience shallow flooding (one foot deep on the average), areas above the 100-year flood level but below the 500-year flood level, and areas of minimal flooding. This information comes from the Firm Flood Insurance Rate Map (Federal Emergency Management Agency, 1982).

There is very little documentation of flooding in this unit. Schlicker and others (1972) noted damage to beachfront houses in the January 3, 1939 storm. That was a 75 year storm according to the U.S. Department of Housing and Urban Development (1978). They also mention damage in the December 1967 flood. In both cases the damage was attributed to surf-swept logs.

Erosion

This area has had episodic minor erosion (tens of feet). The erosional escarpment of recent erosion (probably the winter of 1982-83) has healed in the central portion of the management unit and is almost healed on the north end. This erosion apparently effected the entire shoreline in this unit and resulted in about 5 to 20 feet of shoreline retreat. The condition of the foredune suggests that widespread but minor shoreline retreat might be common in this unit. Local erosion of the shoreline has also occurred where rip current embayments have reduced the width of the beach.

Accretion

In 1920, the shoreline in this unit was apparently near the present location of Pacific Street (Walker, 1983). By 1939 land had accreted west of Pacific Street and houses had been built on the new land. From 1920 to 1939 there may have been about 100 feet of accretion (over 5 feet per year). Aerial photographs indicate that many homes built on the new land experienced flood damage in the storm of January 1939. The newly formed foredune survived the storm but was severely eroded on the west side, and it was apparently overtopped throughout the unit. From 1939 to 1964 there was an average of 50 feet of accretion (2 feet per year). From 1964 to 1977, there was as average of about 30 feet of accretion (2.3 feet per year). The net affect of the erosion and accretion in this unit is a narrow foredune with relatively low relief. After erosion episodes, there is an erosional escarpment. The escarpment is healed by wind blown sand, and the shoreline continues to slowly accrete.

Present and Future Foredune Stability

This foredune management unit has had slow accretion interrupted by minor erosion and shoreline retreat since 1939 and possibly since 1920. From 1920 to 1939 the accretion rate may have been in excess of 5 feet per year. After 1939 the average accretion rate has been a little over 2 feet per year. There is no evidence that this trend will stop or reverse in the foreseeable future. Erosion events will occur in the future. Some will be local (about 200 to 1000 feet of shoreline) and widespread erosion will involve all or nearly all of the unit. Maximum shoreline retreat will generally be less than 30 feet. The unique coincidence of two erosion events in one year could almost double this rate of retreat. Eroded areas will repair naturally and then continue to slowly accrete.

Flooding and damage to structures has occurred here and will occur in the future. Eventhough this management unit is not suitable for foredune grading, management of the foredune could decrease the potential for future flooding and damage. The goal of the management would be to build up a higher foredune to reduce wave overtopping. This may not be desirable to many residents and businesses because of loss of views. Management is recommended to include minor grading to smooth the foreslope and crest of the foredune, selective planting of European beachgrass and fertilization of the beachgrass.

ROCKAWAY BEACH MANAGEMENT UNIT

General

This management unit is almost 1100 feet in length; the shortest management unit in the study area. It extends from the area of influence of Rock Creek to the area of Saltair Creek. The foredune is relatively low and irregular because of episodic erosion and accretion, patchy vegetation, and wind erosion. The unit is subject to ocean flooding because of the low height of the foredune. There has been local shoreline erosion, mostly related to the occurrence of rip current embayments. Since 1939 there has been accretion of about 100 feet on the north end and about 350 feet on the south end. Foredune grading is not feasible in this unit because the foredune is too low, but management in the form of vegetation management and minor grading could increase flood protection for some developed inland areas. However, the amount of increased protection for existing development would be small.

Vegetation

In this unit, the entire length of the foredune foreslope area has experienced episodic accretion and repeated wave erosion. As a result, the vegetation line is very uneven with large gaps and wind scour troughs. This problem is magnified by some grading and by heavy foot traffic on the north portion. The present vegetation is scattered clumps of European beachgrass down to the winter high tide line.

As illustrated on the Technical Report Map, this foredune crest area lacks any consistent height or width. The present dominant plant species is beachgrass, growing in a series of hummocks. The condition of the grass varies in relation to the eolian beach sand deposits that have moved over the foredune.

Vegetation on the backslope in this area is weak with old stands of European beachgrass scattered throughout on hummocks and remnants of older foredunes. The area's rough nature, especially in the southern portion, indicates past cycles of severe erosion and recovery.

Flooding

The 100-year base flood elevation in this unit is 23 feet. Grading would be allowable on the foredune only if it exceeded 27 feet in elevation. The highest foredune elevations are at the south end of this unit. The highest elevation is 23 feet. The lowest mapped foredune areas are on the north end of his management unit (around 17 to 18 feet in elevation).

The foredune and the immediate inland area has been flooded in the past and will flood again in the future. There are no specific reports of ocean flooding in this area, probably because the existing development is on a higher stable dune east of the present foredune. Dwellings and commercial structures are on or protected by land in excess of 22.5 feet in elevation.

Erosion

Aerial photos and vegetation indicates that an unknown but substantial amount of shoreline retreat has periodically occurred in this management unit. The erosion appears to have been related to rip current embayments and to unit-wide shoreline retreat. The north end of the unit appears to have been particularly prone to rip current embayment formation. The amount of shoreline retreat is not evident on the Technical Report Map because of limited aerial photo coverage. What is evident from the aerial photo mapping of shorelines is that from 1939 to 1966 there was less than 70 feet of shoreline accretion. What the shoreline mapping does not show is shoreline retreat in January 1953 and in the spring of 1962. From 1966 to 1970 there was little shoreline erosion, and there was up to 150 feet of accretion. From 1970 to 1984 there was little accretion, probably because of erosion in 1972, 1974, 1976, 1977, 1978, and the winter of 1982-83.

Accretion

This management unit has had slow accretion, but ocean erosion and wave overtopping has resulted in a very irregular rate of accretion. From 1939 to 1977 there was about 130 feet of accretion on the north end of the unit (about 3.4 feet per year). In the same period there was about 230 feet of accretion at the south end of the unit (about 6 feet per year). However, from 1939 to 1966 there was very little net accretion (see the Technical Report Map). There had probably been more accretion in the period from 1939 to 1966, but apparently extensive shoreline retreat occurred in 1962. From 1966 to 1970 there was very little erosion and the shoreline accreted rapidly. From 1970 to 1977 there was only a small net amount of accretion, probably because of shoreline retreat in the storms of December 1972, February 1976 and October 1977. There has been little change in the shoreline since 1977, probably because of shoreline erosion in February 1978 and in the El Nino period in 1982 and 1983.

Present and Future Foredune Stability

As in the other management units previously discussed in this report, there has been slow accretion in this foredune management unit area. However, the low and irregular foredune and the evidence of extensive shoreline retreat indicates that the present foredune is unstable and subject to ocean erosion and wave overtopping. The only stable landforms are east of the 1939 shoreline shown on the Technical Report Map.

Foredune grading is not feasible in this unit because of the low elevation of the foredune crest and because of the potential for future shoreline retreat. Management of the foredune by minor grading and increased beachgrass coverage would improve the ability of the foredune to protect inland areas from ocean flooding and erosion. However, there is the attendant danger of fostering new land development in low elevation areas west of existing development. Further, establishment of a higher and broader foredune is limited by a relatively short beach area available as a source of wind transported sand for a foredune. If foredune management is attempted in this area it should only occur if there is an effective restraint on land development west of the line of existing development.

ROCKAWAY SOUTH/TWIN ROCKS MANAGEMENT UNIT

General

This management unit extends from the area of influence of Saltair Creek to the area of influence of the combined Spring Lake Outlet and Watseco Creek, a shoreline distance of about 1800 feet. The highest elevation on the foredune is about 23 feet. The lowest part of the foredune is about 16 feet in elevation. The 100-year base flood elevation is 24 feet on the north end and 19 feet on the south end. The foredune is not high enough to allow foredune grading under Goal 18 provisions. Dwellings east of the foredune are only subject to minor ocean flooding under existing conditions in the event of an 100-year flood. This unit has had slow accretion since at least 1939. There have been periods of local and unit-wide erosion but natural repair of the foredune and accretion has followed the erosion events.

Vegetation

The vegetation in the foreslope area of the foredune is recovering from recent erosion. European beachgrass is the dominant species, but coverage is sparse. As a result of the sparse beachgrass coverage and natural foredune recovery from erosion, there is some minor wind erosion, sand deposition, and uneven development of the foredune.

The crest of the foredune is irregular because of the repeated episodes of erosion and the resultant wind erosion, sand deposition and uneven development of beachgrass coverage. The dominant vegetation on the crest is European beachgrass.

This backslope area is one of the most stable of the management units. Species present, besides old nutrition starved beachgrass, are the typical climax dune species. Surface grading in previous years appears to have caused no severe or persistent vegetative problems, probably because of the shallow depth of excavation.

Flooding

The base flood elevation is 24 feet in the northern portion of this unit and 19 feet on the south end. The foredune is only 16 to 23 feet in elevation and is subject to overtopping in a major flood. Existing structures are on an old and stable dune ridge about 250 to 400 feet east of the active foredune. The structures are generally at an elevation of 20 feet and many of the structures would be subject to flooding in a 100-year flood. Much of the flooding would be shallow in depth, but those structures subject to velocity flooding (wave action) could be damaged by the wave action and surf-swept drift logs.

Erosion

Overall this unit has accreted despite episodes of erosion. Erosion has been both unit-wide and local. Local erosion is typically related to the occurrence of rip current embayments in the nearshore that narrows the width of the beach. The Technical Report Map illustrates shorelines mapped from aerial photos, but photos are avilable for only a limited number of years.

The mapped shorelines indicate wide-spread erosion between 1970 and 1977 and between 1977 and the mapping for this study (1984). This unit-wide erosion probably occurred in December 1972, February 1976, October 1977, February 1978 and in the winter of 1982/1983. Previous episodes of wide-spread erosion undoubtably occurred but are impossible to document with the available information. Available information indicates that wide-spread erosion has resulted in shoreline retreat of 50 feet or less.

Rip current embayments have resulted in local shoreline erosion of about 500 feet in length and about 50 feet in depth in the period from 1966 to 1984.

Accretion

Overall there has been net accretion of the shoreline in this management unit since at least 1939. Aerial photos taken in April 1939 indicate that this area experienced accretion shortly after the completion of construction of the north jetty at Tillamook Bay in 1912, but the onset of accretion began at an unknown time. From 1939 to 1984 there was net accretion of as little as 200 feet on the north end of the unit and as much as 350 feet on the south end. This translates to an average net accretion rate from over 4.4 feet per year to almost 7.8 feet per year. From 1966 to 1970, apparently a period of little ocean erosion, there was an average rate of 20 feet of accretion per year. From 1970 to 1977, a period of time with many shoreline erosion events, there was no net accretion.

Present and Future Foredune Stability

The foredune is insuffcient in height to allow grading. There has been accretion of the shoreline, but episodic local and unit-wide ocean erosion combined with wind erosion has resulted in a foredune that is low and irregular in elevation. Because there is no evidence of change in shoreline processes we believe that the past process of slow accretion will continue. It can also be assumed that unmanaged future foredune development will continue to produce a foredune that is low in elevation and irregular because of the ocean and wind erosion.

Vegetation management could produce a more stable foredune with increased protection for existing inland structures. However, management would necessarily include monitoring of the foredune condition and periodic maintenance of the foredune vegetation.

Presently, because of the probability of velocity flooding behind the foredune, there should be no development of structures west of the existing line of dwellings along Breaker Avenue. Any development west of the existing line of dwellings would be subject to the hazards of velocity flooding, surf-swept driftwood, wind erosion, wind-blown sand deposition, and shoreline retreat. Further development in this area should only be allowed if there is a plan for perpetual foredune management, demonstration of long-term stability of the managed foredune, and assurance of a future free from velocity flooding.

CREEK OUTLETS - DESCRIPTIONS AND RECOMMENDATIONS

CRESCENT LAKE OUTLET

General

This shoreline area is illustrated on Figure __. Crescent Lake outlet has influenced about 1650 feet of the shoreline. Before the stream was constrained by a highway and railroad bridge the creek probably migrated over a shoreline area that extended further to the south. The drainage area of this creek includes Finney Creek, Steinhilber Creek, Lake Lytle, and Crescent Lake.

The foredune in the creek area of influence is poorly developed and low in elevation, typical of the area of influence of creek outlets in the study area. As a result the area behind the foredune is prone to ocean flooding.

This creek outlet area also displays a trait characteristic of other outlets in the study area: erosion and accretion is larger and the area of influence is larger north of the outlet than to the south. Presumably this is because storm waves approach the shoreline and run up on the shoreline from the southwest. Waves generated by southwesterly winter storm winds are higher than northwestly summer waves, and winter tides are generally higher than summer tides. As a result the northern shorelines, which face winter waves tangentially, take the brunt of the energy in the waves and in wave run-up. Accretion of the shoreline north of the creek outlets therefore might occur in periods when winter storm driven waves do not coincide with high tides. Unfortunately the aerial photos used in this study do not confirm or disprove this hypothesis.

Vegetation

The foredune and the European beachgrass present is poorly established on the north side of this creek outlet area. The most northerly 340 feet of this unit has a very thin active dune area with an older stable dune immediately adjacent on the east. Further south on the north side there are foredune fragments up to about 19.5 feet in elevation and dune hummocks but the average dune height is less than 18 feet in elevation and the area is poorly vegetated. Just north of Crescent Lake Outlet there is an erosion escarpment that is partially protected by a revetment placed to protect the railroad tracks. The beachgrass is also sparse here.

South of Crescent Lake Outlet there is a low foredune that is very sparsely vegetated on the foreslope because of recent erosion. Part of the crest and all of the backslope area is well colonized by beachgrass indicative of recent stability, but the foredune is generally thin and largely below 20 feet in elevation.

Flooding

The base flood elevation for the 100-year flood is 19 feet. Low spots in the foredune (about 16 feet elevation on the north end and less than 16 feet on the south) would allow for flooding behind the foredune.

Erosion

The north side of Crescent Lake outlet has experienced substantial erosion and retreat of the shoreline. From 1939 to 1964 there was over 200 feet of erosion. From 1939 to 1977 there has been as much as 230 feet of shoreline retreat. There have been periods of shoreline accretion (1964 to 1979) but erosion has dominated.

The south side of Crescent Lake outlet has been very stationary in the period from 1964 to 1984. Observations made in the field in 1985 indicate that this apparent stability is the result of frequent erosion of the shoreline and a slow rate of natural repair to the foreslope of the shoreline.

Accretion

The northern half of this creek area has had more erosion that accretion. There has been a small amount of accretion on the northernmost end of the area of creek influence. The accretion totaled about 90 feet from 1939 to 1970 (2.9 feet per year). There was then shoreline retreat between 1970 and 1977. From 1977 to 1984 there was net accretion, but the newly accreted shoreline area is a low elevation foredune foreslope and is subject to renewed erosion in the near future. From 1964 to 1970 there was accretion north of Crescent Lake outlet of over 100 feet, but between 1970 and 1977 there was a nearly equal amount of shoreline erosion.

The southern half of this creek outlet area had at least 150 feet of accretion since 1939, but since about 1964 there has been a net balance of erosion and accretion and a relatively stationary shoreline.

Present and Future Foredune and Shoreline Stability

The northern portion of this area of influence of Cresent Lake outlet has a low, poorly developed foredune. The area has expeienced extensive erosion and moderate accretion, and as a result has had a very unstable shoreline. The low elevation of the foredune means that severe ocean flooding will overtop the foredune and flood the State Wayside area.

The south side of the creek area has been relatively stationary since 1964 and this will probably continue. This condition is partially the result of the fact that the south side of creek outlets are not as prone to erosion from winter storm waves-waves that approach from the southwest. The southern shoreline will not experience substantial accretion because this area is sheltered from wind-blown sand deposition from southwest winds by the Lake Lytle Oceanfront shoreline and largely protected from northwest wind transported sand by Crescent Lake Outlet.

ROCK CREEK

General

This shoreline segment is about 1500 feet in length. About 66% of the shoreline is north of the creek outlet and about 34% is south of the creek outlet. Elevation of the foredune crest averages about 22 feet north of Rock Creek (16 feet to 28 feet is the range of elevations). South of Rock Creek the crest elevations range from 16 feet to almost 22 feet. Commercial and residential structures behind the foredune range from about 14 feet to over 25 feet in ground elevation.

Most of the shoreline has accreted since 1939 but shoreline advance has been interrupted periodically by episodes of local erosion. As a result the foredune is locally low in elevation and thin. The lowest elevations are near Rock Creek and this is the area where there has been the most damage from ocean flooding and surf-swept driftwood.

Vegetation

This shoreline segment is highly disturbed and this is reflected by the sparse nature of the vegetation. The dominant species along the shoreline is European beachgrass but the distribution is irregular because of heavy foot traffic and past erosion. North of the creek outlet there is a revetment that was placed to reduce shoreline retreat. Further north is a shoreline foreslope that has experienced repeated episodes of erosion. In this area the crest of the active foredune has much better beachgrass coverage than the foreslope and there are secondary species, such as beach pea present.

South of Rock Creek the foredune is sparsely vegetated because of heavy foot traffic, past grading, minor wind erosion, and episodic ocean erosion. The parking lot is protected by a rock revetment, and there is almost no foredune. The foreslope, crest and backslope are hummocky and sparsely vegetated with European beachgrass.

Flooding

The base flood elevation is 23 feet on the Rock Creek shoreline. Only the northern third of the shoreline in the area of creek influence is above this elevation. Foredune elevations are about 16 feet near the channel of Rock Creek. Even moderate flooding has been able to reach areas behind the foredune and wave- tossed logs have been tossed on to and across Highway 101.

Erosion

There has been net accretion of most of the shoreline north and south of Rock Creek, but significant erosion has resulted in only a small amount of total accretion (see Figure __). Past erosion has resulted in the placement of rock revetments on both the north and south shorelines, as well as 200 feet of the channel of Rock Creek. Some of this riprap is now partially buried under wind transported sand.

Shorelines mapped from aerial photos indicate that there was up to 40 feet of erosion north of Rock Creek sometime between June 1970 and December 1977, possibly in December 1972, December 1974, February 1976, and/or October 1977. There is no evidence of the amount of erosion that has occurred south of Rock Creek, but vegetation, limited accretion and the condition of the foredune indicates that erosion of a few tens of feet has been common in the past.

Accretion

Most of the shoreline in the area of influence of Rock Creek has had shoreline advance since 1939 (Figure __). There was as much as 150 feet of accretion at the north edge of the area of creek influence from 1939 to 1984 (over 3.3 feet per year). The amount of accretion diminishes to zero near Rock Creek. The southern edge of the creek influence area has had as much as 170 feet of accretion between 1939 and 1984 (about 3.8 feet per year). The net amount of accretion diminishes to zero near Rock Creek.

Present and Future Foredune and Shoreline Stability

The shoreline in the Rock Creek area of influence has experienced net accretion except near the creek channel. This trend is expected to continue, but episodes of shoreline erosion are also common in the past and will continue to occur. Erosion will be most common north of Rock Creek. Moderate ocean flood and erosion episodes have resulted in as much as 40 feet of shoreline retreat. The maximum amount of future shoreline retreat that should be anticipated is about 120 feet. This amount of erosion would occur from one severe erosion event or several moderate erosion events in one or two years.

Inundation will continue to occur periodically near Rock Creek and behind the foredune as a result of both fresh water flooding and ocean flooding. Ocean flooding could affect areas behind the foredune as often as once every 10 years.

SALTAIR CREEK

General

Saltair Creek influences about 2100 feet of shoreline (Figure __). About 60% of the affected shoreline is north of the creek and about 40% is south of the creek. The elevation of the foredune crest ranges from about 15 feet to almost 29 feet north of the creek and from about 14 feet to 23 feet south of the creek. The foredune is relatively broad (about 150 wide at the widest) at the north end of the creek area of influence, but the width and height diminishes toward the creek. South of Saltair Creek there is almost no foredune. Instead there is a broad, relatively flat topped sand ridge that is up to 300 feet wide and about 20 to 22 feet in elevation. Aerial photos and field evidence indicates that this area has been graded flat. The grading combined with periodic shoreline erosion and a limited amount of wind transported sand has resulted in almost no foredune development like at the other creek outlet areas.

Vegetation

The foreslope of the foredune in this creek influence area is recovering from recent erosion. The vegetation line is uneven and European beachgrass occurs in clumps and patches separated by open sand areas of wind and ocean erosion. North of Saltair Creek the crest and backslope areas are mostly occupied by European beachgrass in stands of various age. Old nutrition starved stands of beachgrass occupy hummocks and intervening areas are occupied by moderately dense to mostly sparse stands of younger beachgrass and areas of open sand. The crest and backslope areas south of Saltair Creek have been graded. European beachgrass predominates but a lack of wind transported sand from the beach has resulted in a relatively unvigorous stand. In addition to grading there appears to have been some mowing of beachgrass and some attempts to establish lawns.

Flooding

The base flood elevation for the 100-year flood is 20 feet north of South 6th Avenue and 23 feet to the south. Velocity flooding would affect several dwellings near Saltair Creek in an 100-year flood (see Figure __). The area near the creek, particularly north of the creek, has been subject to velocity flooding, shallow flooding and wave-swept driftwood in past storms in January 1953, October 1960 and December 1967. Several houses were pushed off of their foundations and one house was pushed on to the railroad tracks in the October 1960 storm (Walkes, 1983). Cinder block and concrete walls and a rubble rock dike now provide a limited amount of protection to houses north of the creek.

Flooding has occurred here in the past and will occur in the future because of the low elevation of the foredune near Saltair Creek. The base flood elevation for the 100-year flood is 20 feet at the creek and the land adjacent to the creek is only 14 to 16 feet in elevation. Dwellings near the creek and behind the foredune are about 14 feet to 18 feet in elevation at the ground level.

Erosion

The shoreline within the area of influence of Saltair Creek has experienced slow accretion but there has been periodic shoreline erosion. Between 1966 and 1970 and between 1977 and 1984 there was about 40 feet of shoreline retreat just north of the creek. There is evidence of erosion between 1970 and 1977 of between 40 and 100 feet further north on the shoreline. South of Saltair Creek there was local erosion of 300 to 400 feet of shoreline between 1966 and 1970. Shoreline retreat appears to have been about 30 to 40 feet in that episode. A similar amount of erosion occurred in the same location between 1977 and 1984. Natural foreslope repair was still occurring in 1985.

Accretion

The area north of Saltair Creek has experienced up to 300 feet of accretion from 1939 to 1984 (6.7 feet per year). According to aerial photos there was very little accretion from 1939 to 1953 or if there had been accretion it was followed by shoreline retreat, possibly in the storm in January 1953. Sometime between 1953 and 1966 a rubble rock dike was built north of Saltair Creek. A similar structure on the south side of the creek was probably place at the same time. The dike might have contributed to the increased rate of accretion up to about 1970. From 1966 to 1970 there was 200 feet of shoreline advance (about 50 feet per year). From 1970 to 1977 one area had 100 feet of accretion (up to 14.3 feet per year), but the average accretion was 40 feet (5.7 feet per year). From 1977 to 1984 there was almost no accretion.

South of Saltair Creek there was almost no net accretion near the creek between 1939 and 1966. Near the southern edge of the creek influence area there was up to 70 feet of accretion between 1939 and 1966 (2.6 feet per year). From 1966 to 1970 there was up to 30 feet of accretion (7.5 feet per year). From 1970 to 1977 there was up to 40 feet of accretion (5.7 feet per year).

Present and Future Foredune and Shoreline Stability

The shoreline influenced by Saltair Creek is notably different north of the creek compared to south of the creek. The northern area is similar to other creek outlets in that the rates of erosion and accretion are higher than south of the creek. Because the accretion occurred rapidly, the area behind the foredune is low in elevation. The foredune diminishes in height and width close to the creek. It is subject to ocean erosion and flood overtopping.

The area north of Saltair Creek has demonstrated progressive accretion, but there appears to have been periods of extensive erosion and ocean flooding. The shoreline north of Saltair Creek must be considered as unstable and prone to sudden shoreline retreat as well as ocean flooding. This is demonstrated by a breach in the foredune about 500 feet north of the creek.

The shoreline south of Saltair Creek has only a small amount of total accretion, and near the creek the shoreline has been eroded as much as it has accreted. Near the creek this shoreline is subject to erosion that could exceed historic amounts. Dwellings near the creek and behind the foredune are subject to ocean flooding, perhaps as often as once every 10 to 15 years. Further south from the creek the foredune has been graded to an elevation of about 21 feet where the 100-year base flood elevation is 23 feet. The area is subject to severe floods but the foredune area is broad and more resistant to ocean erosion than thin foredunes. The shoreline in this area should continue to accrete slowly but could be subject to local shoreline erosion greater than historic levels. Erosion could extend to the 1939 shoreline within the next few decades.

SPRING LAKE OUTLET/WATSECO CREEK

General

This shoreline area is influenced by two creeks: Spring Lake Outlet on the north and Watseco Creek on the south. Presently, Watseco Creek flows north for over 2200 feet before joining Spring Lake Outlet and then flowing to the ocean. In 1969 and 1970 the two creeks had separate channels to the ocean. In 1966 the creeks flowed similar to the present. In 1960 they were in separate channels.

After the construction of the north jetty at Tillamook in 1912 there was relatively rapid accretion in this shoreline area. Accretion continued until about 1977. There could have been erosion episodes during that time, but there is no evidence. Wide-spread erosion has occurred since 1977.

Vegetation

European beachgrass is the dominant species in this area but the coverage is very sparse. The foredune foreslope is mostly open sand because of recent erosion. North of Spring Lake Outlet and at the south end of this shoreline unit the foreslope of the foredune has been almost completely eroded in 1983, 1984 and early 1985. The foredune crest north of Spring Lake Outlet is fairly well vegetated with beachgrass and some secondary species. South of Spring Lake Outlet for about 1600 feet there is mostly open sand and scattered areas of beachgrass where there has been wave overwash. This area has only the hummocky beginnings of a foredune. Further south there is a low fordune area with a crest of beachgrass and a small amount of open sand. The backslope in this area is similarly vegetated. North of Spring Lake Outlet the foredune backslope is mostly vegetated with beachgrass but there are secondary species present. Near the row of dwellings on the eastern edge of the backslope there are many climax species such as Shore Pine.

Flooding

The 100 year base flood elevation is 16 feet from slightly north of Spring Lake Outlet to the south end of this shoreline area. North of Spring Lake Outlet the base flood elevation is 20 feet, 24 feet and 19 feet (see Figure __). North of Spring Lake Outlet the foredune is adequate in height to resist all but the most severe ocean floods. The land adjacent to Spring Lake Outlet is over 14 feet in elevation and should be free of all but the most severe floods. South of Spring Lake Outlet there is much low lying area that is subject to flooding, but all of the existing dwellings are above the 16 foot base flood elevation for an 100-year flood.

Erosion

The foredune north of Spring Lake Outlet has eroded significantly since 1977. There was as much as 150 feet of erosion of this high foredune between 1977 and 1984. This erosion involved about 600 feet of shoreline.

South of Spring Lake Outlet at the north end of Pacific Street there is riprap. This was apparently placed in response to shoreline erosion. This erosion could be related to the meandering of Watseco Creek or to ocean wave erosion.

South of Spring Lake Outlet for about 1400 feet there has been a large amount of shoreline fluctuation and erosion as a result of the meandering of Watseco Creek. Further south there has been erosion of the foredune in the period from about 1983 to early 1985. This erosion appears to be related to the El Nino of the same time that produced a net northerly littoral transport of sand. Foredune erosion extended from this area south to the north jetty at Tillamook Bay. There might have been as much as 50 feet of shoreline retreat as a result.

Accretion

There has been extensive accretion in this area as a result of construction of the north jetty at Tillamook Bay. There was as much as 900 feet of accretion from 1939 to 1977 on the south end of this shoreline area.

The central portion of this shoreline has had net accretion, but the meandering of Watseco Creek and ocean erosion has resulted in no net accretion of lands free from the hazards of ocean flooding and ocean erosion.

The northern portion of this creek influence area is similar to the other creek areas to the north. From 1939 to 1966 there was as much as 240 feet of accretion (almost 8.9 feet per year). From 1966 to 1970 there was little or no accretion near Spring Lake Outlet. Further north there was up to 70 feet of accretion (17.5 feet per year). From 1970 to 1977 there was minor erosion about 500 feet north of Spring Lake Outlet, but the rest of this shoreline area accreted about 40 feet (5.7 feet per year). After 1977 there was mostly erosion in this shoreline segment.

The southern portion of the Spring Lake Oulet/Watseco Creek shoreline area has had net accretion since 1939. There was shoreline retreat probably beginning in 1983 that was continuing during the field investigations for this report. From 1939 to 1966 there was 500 feet to almost 700 feet of westerly accretion (18.5 to 25.9 feet per year) near the southern limit of this shoreline unit. From 1966 to 1970 there was about 60 feet of westerly shoreline growth (15 feet per year). There was also northerly growth of the shoreline of up to 200 feet. From 1970 to 1977 there was about 90 feet of westerly accretion (about 12.0 feet per year). In the same time period there was northerly shoreline extention of about 200 feet.

Present and Future Foredune and Shoreline Stability

This shoreline segment is the area of influence of two streams Spring Lake Outlet and Watseco Creek. Overall this shoreline must be considered as unstable, particularly the central portion where Watseco Creek has meandered widely, and there are low elevations and a very poorly evolved foredune. The northern portion is the most stable segment of this area.

The area of creek influence north of Spring Lake Outlet has had up to 400 feet of accretion since construction of the north jetty at Tillamook Bay in 1912. Net accretion continued until 1966 but there may have been periods of erosion. Better aerial photo coverage is available for the period after 1966. The most significant erosion occurred between 1977 and 1984 when up to 150 feet of erosion occurred to a relatively high and broad foredune. Similar instability and even greater erosion could occur in the future.

The central portion of this shoreline segment has been very unstable because of its low elevation and the instability of the channel of Watseco Creek. The future of this area is impossible to predict. However, past trends indicate that Watseco Creek will continue to meander over at least 1500 feet of shoreline, but continued northerly accretion of the shoreline south of Watseco Creek may continue to force the creek into a northerly flow to a confluence with Spring Lake Outlet. It is also possible that sand and driftwood deposition could block the current channel of Watseco Creek forcing the creek to establish a new channel further to the south.

As a result of the past instability of this area and probable future instability, it is recommended that no development be allowed within the mapped setback line. Even with this level of protection some existing development could require structural protection, particularly the development at the south edge of this shoreline segment.

GRADING

Nedonna Beach
Foredune Grading Plan

Introduction

This plan provides detailed recommendations for grading and stabilizing the foredune at Nedonna Beach, Oregon. The foredune is presently high enough in front of most houses (i.e. more from four feet above the 100 year flood elevation) to qualify for grading under Statewide Planning Goal 18 (Beaches and Dunes). Grading is being done to restore ocean and beach views of oceanfront homes whose views have been blocked by dune accretion. Proper placement and stabilization of the graded sand will also repair and strengthen the foredune; improving its function as a buffer to ocean flooding for the entire area. While the recommendations in this report are specific to Nedonna Beach, the recommended grading and stabilization techniques may be applicable to other developed foredunes. Readers should also consider the following:

- This plan is based on a careful evaluation of the sand system for the entire Rockaway-Nedonna shoreline;

- A variety of other human activities can affect stability of the foredune and stabilizing vegetation. An accompanying foredune management plan recommends controls on these activities which need to be followed if these measures are to be effective.

- Foredunes are inherently unstable areas. The grading and vegetative stabilization measures recommended here should improve protection the foredune provides from ocean flooding, but these actions cannot and do not guarantee damage from ocean flooding will be prevented.

OBJECTIVES, AND EXPECTED RESULTS

The overall purpose of this grading plan is to allow crest grading as part of a total program that will strengthen the foredune. This will be done by:

- creating a uniform crest at no lower than 26'. This will involve building up low spots (through a combination of filling and or planting or fertilizing) and limited grading of crest areas.

- widening the foredune in most areas by

  (1) placing excess graded sand from the foredune crest onto the foreslope.

  (2) smoothing the foreslope and fertilizing and planting European beachgrass in poorly vegetated areas to enhance even accretion of sand on the foreslope.

- promoting a new foredune from approximately Western Street to the South jetty to provide a more continuous foredune throughout this stretch of shoreline.

Specific problems for individual areas are described in the subarea descriptions which follow. The Specifications section describes how corrective actions should be undertaken. These recommendations should be followed unless the subarea recommendations indicate otherwise.

The timing of each management measure is important because of the potential for grading to reactivate sand movement which would destabilize the foredune. Generally, management measures should be done in the following sequence:

(During the dormant season for beachgrass -- generally between October and March)

Year 1 Foredune crest grading should be done in qualified areas (i.e., where foredune crest is more than 4 feet above the 100 year flood elevation).

As indicated in the specifications, graded sand should be used to fill low spots on adjacent lots. Portions of the crest that are currently below the base flood elevation should, at a minimum, be filled to the base flood elevation. Crests that are between the base flood elevation and the 4 feet above base flood elevation level, should also be filled. However, these areas may instead be replanted with European beach grass or fertilized if there is an adequate stand of grass.

Any sand not used in filling the crest should be pushed forward onto the foreslope. Further alteration of the foreslope should not occur at this time. (Grading of both areas in the same year will result in sand inundation in the back area.)

The graded area should be immediately fertilized or if the area is poorly vegetated replanted with European beachgrass.

For the area north of Western Street, a "new" foredune should be started by placement of sand fences. This is not a prerequisite for grading but should be done as part of the overall program to strengthen the foredune.

Year 2: Grade hummocky foreslope areas to create a more even foreslope to enhance sand accretion. This should only be done where crest vegetation is adequately established (or recovered) to capture most windblown sand or where temporary stabilization measures such as sand fences are installed. Also no mowing should be done until the foreslope vgetation has recovered from grading.

Areas with more than 50 % vegetative cover should be fertilized.

Expected Results

Year 1: Grading will temporarily result in more open sand in crest areas since dune grass will be bladed off or buried by placed sand. These areas should recover in one growing season.

The crest will be of a more uniform height throughout. However, the total amount of sand in the foredune should not change since sand will simply be redistributed within the foredune system.

Areas with sand fences will begin to accumulate sand, and depending on wind and weather conditions should fill entirely within the first year. The result will be a low (4-5 foot) open sand ridge up to 45-50 feet wide immediately in front of the present foredune. The sand fence may fill at different rates and high winter storm waves might erode a portion of the dune. (This should not seriously affect the foredune, especially if promptly repaired.)

Sand captured by the sand fences will be sand which would otherwise have accumulated in the foredune or blown behind the foredune or beyond the jetties. Consequently there may be a slight reduction in the rate of sand accretion on the existing foredune. However, sand will accrete at normal rates once sand fences have filled.

End of Year 2: Vegetation on graded areas should be substantially recovered or established. Overall the crest should have more and thicker vegetative coverage than prior to grading. Depending on the strength of winter winds the crest may begin to receive some new sand accretion although most new material should be trapped in sand fences or on the foreslope (in ungraded areas).

After grading, reshaped foreslope areas will temporarily have a reduced ability to trap windblown sand. This will increase sand accumulation slightly on ungraded crests. (Prompt replanting or fertilizing of European beachgrass will reduce this effect.)

Sand fenced areas will have been planted with European beachgrass. In its first six months the new grass will capture only a little sand. Six to twelve months ater planting the grass should be well established enough to capture sand at a rate equal to other areas.

End of Year 3: Vegetation on graded crests should be fully recovered, and the entire crest should be well vegetated. Mowing may temporarily reduce height of the grass, but when done during the summer season and properly fertilized, it should grow back thicker. Crest areas should be receiving only small amounts of sand accretion.

Foreslopes reshaped during the previous year should have well-established vegetation that is trapping most of the sand accretion occurring.

Vegetation in sand fenced areas should also be well established except in isolated pockets of erosion (which should be in various states of repair depending on how recently they occurred). The "new" foredune should be trapping most of the windblown sand. The sand fenced dune should grow at a rate of 18 to 24" per year.

Years 5-10

Notwithstanding major flood events the foredune should continue to grow oceanward. If foreslope vegetation is properly established and maintained throughout the Nedonna area sand accretion at the crest should be very slight or could be stopped altogether. Instead windblown sand will be entirely trapped by the widening foreslope. The foreslope should prograde slowly as accretion occurs.

In areas where the foredune is widened through placement of a sand fence the existing foreslope and crest will receive less and less windblown sand as the "new" foredune grows in height. The result will probably be a slight trough between the "old" foreslope and the "new" crest (actually an elongated foreslope). The new foredune should continue to grow in height and may eventually (10 years or more) be as high as the existing crest. (It would be appropriate to allow some sand to fill in the "trough" area through periodic mowing after the "new" foredune is well established.)

Some foreslope areas will likely be eroded by ocean storm waves. It is assumed that where more than 50% of the foreslope is eroded that the eroded slope will fill naturally or be shaped and replanted. These areas will recover, albeit inconsistently with adjacent areas. While these areas are recovering hummocks may develop on adjacent foreslope areas as a result of the eroded area's reduced ability to capture windblown sand.

SUBAREA ANALYSIS AND RECOMMENDATIONS

Subarea A: South Jetty Subarea

Setting

The foredune in this subarea is virtually non-existent. Prior to rehabilitation of the jetties in 1981-82, the shoreline receded at a northeasterly angle from in front of the jetty parking lot to the jetty. There are a number of small hummocks above the high tide line but most of this area slopes gently to an open sand area at an elevation of 10-12 feet. The absence of a well-defined foredune and stabilizing vegetation is probably the result of wave action and a rip current in this area prior to jetty reconstruction. Since jetty reconstruction, the beach has accreted substantially. Sand that is accumulating is widening the beach oceanward and the profile of the beach appears to be flatter. Because of the absence of stabilizing vegetation sand is being blown across this area both into back areas and across the jetty into the Nehalem River.

As noted elsewhere maintenance of the jetties is critical to the stability of the beach at this location. If the jetties are not maintained their effect on ocean waves will steadily lessen and the area will likely erode back to its pre-rehabilitation configuration.

The accreted sand in this entire subarea (i.e. sand accumulated since jetty rehabilitation) should be considered a natural 'bank account' for the shoreline south to Tillamook Bay. Much of the current accumulation is the result of net northerly movement of sand from El Nino. This sand may be eroded away as the beach system adjusts back to the normal zero net drift pattern. This entire open sand area is very unstable because it is subject to ocean and river flooding or erosion and should not be developed.

Absence of a foredune in this subarea means sand is being blown over the jetty and to inland areas and lost to the sand system. The absence of a foredune also creates a low opening for flooding into back areas.

Recommended Measures:

1. Steps should be taken to establish a new foredune in this area to capture accreting sand and to provide improved flood protection to back areas. The foredune should be extended due north to the jetty from the existing foredune south of the jetty parking lot. The foredune could be encouraged through plantings of european beachgrass alone or by placement of sand fences followed by beachgrass plantings once fences have filled.

2. This area does not qualify for crest grading because of its elevation and the fact that there are no homes here. No other grading appears to be appropriate here for the forseeable future.

3. Emergency access across this area to the beach along South jetty should be provided for. This can best be done by providing a due east-west crossing wide enough for a single vehicle (10-12 feet). This should be located close to the jetty. The existing access across the foredune at the jetty parking lot should be fenced off.

4. The undeveloped area behind the vegetation line is subject to ocean and riverine flooding. No development should occur in this area unless there is a guarantee that the jetties will be maintained for the life of the proposed development.

Subarea B: Jetty Parking Lot Subarea

Setting

The foredune at the jetty parking lot has been seriously damaged by the vehicle traffic and foot traffic across the dune. Vegetation have been completely destroyed and the foredune is much lower than the areas to the South. Access at this location is needed for emergency vehicles to conduct search and rescue at the south Jetty. The parking lot is also the only public access north of the Manhattan Beach Wayside with off-street parking.

Recommended Measures

1. The foredune should be stablized to prevent sand deposition into parking lot and to inland areas. Access for emergency vehicles and pedestrians should be provided and designed to avoid harming the foredune.

2. The foredune should be restored with a combination of sand fences and dunegrass plantings. Fences should be placed to widen the dune seaward to provide increased erosion protection.

3. Sand fences should be constructed with openings to allow pedestrian access across the foredune while sand is accreting. These accesses should be oriented east-west to avoid wind and erosion.

4. Once vegetation is well-established on the dune the access ways should be fenced and revegetated and permanent accessways across the rehabilitated foredune should be opened.

5. The foredune crest is much to low to allow crest grading and there are no oceanfront homes in this subarea. Grading in this subarea should be limited to toreslope shaping necessary to prepare the site for beachgrass plantings.

6. Vehicles should not cross the foredune at this location. Instead they should travel due North of the end of Beach Drive and cross the low beach or new foredune farther North closer to the jetty. The access should be signed "for emergency vehicles only," to limit access to emergency, salvage and similar operations. Where emergency access across the foredune is necessary it can occur at the pedestrian accesses described above.

   Vehicle access at this location should be limited to search and rescue at the jetty or on the beach. Vehicle access to the beach for other purposes should occur at the south end of the Manhattan Beach Wayside. The access there is much better oriented and the dune is better developed to withstand vehicle impacts.

Subarea C: Park Street Subarea

Setting This portion of the foredune has been developed with homes. The foredune itself, is low (24-26 feet) and narrow (averaging 130-170 feet in width). The foredune is poorly to moderately vegetated. Cover in backslope areas is 100% but crest areas are about 40-60% and some graded lots have no cover. The foredune is narrowest and least well vegetated on the north and gradually widens and is better vegetated towards the south.

The condition of the foredune is a result of previous erosion, grading and house construction. The four existing homes north of Park Street are all located on the forward portion of the crest. This has required grading to keep the houses from being inundated with sand. The house immediately north of the end of Park Street is lower than the crest of the foredune on adjacent lands.

A rip-current centered near Park Street caused substantial erosion of this subarea in the winter of 1977 and 1978. The foredune eroded back at this time. The foredune may also have been graded to a slightly lower elevation as rip-rap was installed. Virtually the entire shoreline was rip-rapped at that time to prevent further erosion. (Rip-rap was placed in an even line parallel to the shore 20-40 feet in front of the homes). Since rip-rapping in 1978, the foredune has begun to recover and re-establish itself. Except in two locations where view grading has occurred the foredune now completely covers the 1978 erosion and rip-rap.

The pattern of hummocks and sparse vegetation indicate the area has filled naturally, without man-made assistance. (Property owners confirm this observation.) Presently, the foredune expands 80 feet in front of the homes (varying from 60 feet to 90 feet).

Management Recommendations

The foredune in this area needs to be stabilized through increased vegetative cover and strengthened in both width and height. Several specific steps are appropriate to accomplish this.

1. Plant open sand areas and areas with less than ____ % cover with European beachgrass per beachgrass planting instructions. Plantings should be blended into the existing line of vegetation or adjacent unplanted lots.

2. The foredune from Park Street North is too low to qualify for grading of the foredune crest. Grading here should be limited to smoothing the foreslope for planting of beachgrass.

3. Three of the eight houses south of Park Street qualify for some grading of the foredune crest. The priority locations for placement of graded material are low spots in adjacent crest areas first and low or narrow portions of the foreslope second. (see grading plan map)

   (a) areas with 40 - 60% vegetative cover, should be replanted with European beachgrass per the specifications to provide more uniform vegetative cover.

   (b) low spots (i.e. below 26'), particularly graded areas or breachs in the crest of the foredune should be stabilized with parallel sand fences to promote even sand filling followed by beachgrass plantings. Planting vegetation alone is an acceptable alternative.

4. The new foredune to be created by sand fencing extends throughout this area as shown on the maps.

Subarea D: Riley Street Subarea

Setting

The foredune in this subarea is very similar to the Park Street Subarea (Subarea C) with the following differences:

- The foreslope is noticeably wider (75-80 feet vs. 50-60 feet) and has slightly less beachgrass cover.

- The crest has been recently graded (i.e. within the last two years) in front of several houses in this area. The crest is at approximately 24.5 feet or 1.5 feet below the approved grading elevation.

- The portion of the foreslope immediately forward of the crest is steeper than the subarea to the north, though both areas are characterized by hummocky foreslopes.

Beachgrass in the graded areas is recovering well from grading.

There is also a depression in the foredune north of the northern house in this subarea apprently caused by vehicle access. The depression may have been the result of use of the site as a staging area for placement of rip-rap in 1978.

Management Recommendations

1. Crest grading is only appropriate for the southernmost house in this subarea. Graded material from this lot should be used to fill the crest on the adjacent lot to 26'. Alternatively, the may be graded onto the foreslope if the adjacent area is stabilized through beachgrass plantings and fertilization.

2. Foreslope grading is appropriate in this area and is needed to create a more even slope. Foreslope grading will provide a better slope for planting of beachgrass to enhance sand accretion.

3. A new foredune should be constructed with sand fences in this subarea in the locations shown on the map. The new foredune should be tapered into the existing wider foredune to the north.

Subarea E: Western Street - Sunset Street

Setting

The foredune in this subarea is wider, taller and better vegetated than those to the north. The crest averages

50 feet in width and height varies from 25 to 30 feet. In this subarea, the foredune is progressively wider and better vegetated to the south.

The foredune in this subarea is in better condition than the Riley Street subarea because homes are set back slightly further, there has been less alteration of the foredune and no recent ocean erosion. Actually the homes are located on the crest of an 'older' foredune. There is a slight trough in front of this "older" foredune and an apparent, though poorly formed, crest and foreslope in front of the trough. (See generalized cross section)

The 1977-78 erosion event appears to have tapered out at the edge of this subarea; only the four houses north of Western Street were rip-rapped at that time. Also the Northernmost rip-rap is located 20-30 feet further west than rip-rap on lots to the south suggesting less erosion occurred here.

Much of this variation in the crest, which varies in height from 25 to 30 feet, is the result of unevenness of a naturally formed foredune. It is also the result of grading of the foredune crest. (____ of the ______ built lots in this subarea have been graded.) The crest of the foredune in the middle of this subarea (between cross sections 23 and 24) occurs about 50 feet landward of the crest in the remainder of this area. This sinuous crest creates an opportunity for both wind-blown sand and severe ocean storm waves to overtop the foredune at this location.

The foredune west of Western Street has been not fully recovered from breaching that appears to have occurred in 1977-78 when it was used as an access way for placing rip-rap. While the site has covered with sand it is not vegetated and the crest is 6 to 8 feet lower than on adjacent lots north and south.

Public pedestrian access appears to have occurred west of the end of Western Street. While the access point is lower than surrounding areas, lowering may have been caused by access for placement of rip-rap in 1978 and subsequent grading of the lot immediately to the south rather than pedestrian use. Nonetheless, the crest is bare for 25-40 feet in this area.

Management Recommendations

1. Low spots in the foredune should, at a minimum, be planted with European beachgrass to encourage growth in the height of the foredune in this area. In particular, the breach at the end of Western Street should be planted, preferably after use of sand fences to raise the elevation of the crest at that location.

2. Many of the lots in this area presently qualifies for some crest grading. The amount of sand to be graded will not be adequate to fill low spots up to the recommended crest elevation (26'). Consequently, lower crest lots that do not receive graded sand should encourage crest growth by applicaton of fertilizer and planting bare areas with european beachgrass.

Subarea F: Lark St. - Beach St. Subarea

Setting: This stretch of the foredune is consistently higher, wider and better vegetated than the areas to the south. All of the homes in this area are located 25-100 feet landward of the crest. Most are located on an older foredune just west of Beach Drive. These are generally the older oceanfront homes in this subarea, and were apparently built before the present foredune accreted to its current height.

The backslope in this subarea is well vegetated. There is a complete cover of european beachgrass, with a mix of secondary vegetation including some small shorepine. There are alos several noticeable depressions in the foreslope.

The crest in this area is wide (100-125'), well - vegetated, with an even low-relief characteruized by flat areas and numerous low hummocks. The crest on many of the lots has been graded or mowed but the entire area appears to be at or above the recommended crest elevation and the vegetation is in very good condition.

The foreslope, like that immediately to the North, is 50-75 feet wide, with a gentle slope punctuated by a series of small hummocks (1 to 2' in height). Vegetation cover varies from 25-50% with the southernmost area being better vegetated than the area to the North.

Management Recommendations:

1. Crest grading in this area may involve substantial movements of sand since the crest is two to five feet above the allowed grading elevation. Also, there are few low spots in the crest that need additional material. Consequently most of the graded material should be pushed toward the foreslope further widening the crest.

Specifications

Sand Fencing

Type of Fence:	Four foot high, wooden lath snow fencing or plastic fencing (such as Mirafi). (Green or tan is preferred color for plastic fencing.)
Posts:	Six foot heavy-duty steel posts.
Wire:	14 Gauge galvanized steel wire.
Placement:	Fencing should be located as shown on the plan maps for placement. Fencing should be placed in two parallel rows 30-35 feet apart. Posts should be driven two feet into the ground at 10 foot intervals. Fencing should be firmly attached to each post at the top, middle and bottom. The fences shouldbe anchored with guy wires at 50 foot intervals. End posts should be anchored in three directions at 20 foot intervals. Cover the base of the fence with a mat of rye-grass straw (not wheat straw) 18" wide and 2" deep and cover the straw with sand.
Timing:	Fencing should be placed from November 15 to January 1.
Dunegrass Plantings	Once the sand fences have filled or substantially filled grass should be planted according to specifications for dunegrass plantingfollowing surface grading to provide an even surface for planting.. This should generally be done between January 15 and March 15.

- The foreslope (i.e. in front of the seaward sand fence) to a width of approximately 35 feet should be planted at eighteen inch centers.

- The crest (between the parallel sand fences) should be planted at 18 inch centers.

- The back portion from the shoreward sand fence approximately 24 feet should be planted on 18 inch centers.

Other:

1. Fences must be repaired if damaged by erosion or vandalism.

2. Informational signs should be placed at public access points to explain the purpose of sand fencing projects to encourage public cooperation.

Accessways through sand-fences

Pedestrian or vehicle access through sand fenced areas should be provided according to the following specifications in locations identified on the grading plan map.

- The parallel rows of sand fencing should be cross-fenced at the access to keep pedestrians and vehicles in the accessway and to capture sand.

- Pedestrian accesses should be four to five feet wide.

- Vehicle accesses should be 10-12 feet wide

- A third sand fence should be placed 10-12 feet seaward of and parallel to the main sand fences in front of the access opening. The fence should overlap the opening by at least five feet on each end.

- Accesses must be oriented directly east-west.

- Public access ways should be signed both on the beach and landward to encourage use and discourage crossing the sand fence.

- Once dune vegetation is well established on the stabilized dune the access way should be fenced and stabilized and a new access established through a vegetated portion of the dune.

- European beachgrass should be used and all other recommendations for planting should be followed.

Specifications for Planting European Beachgrass[1]

Planting stock:	The stock to be planted is European Beachgrass (Ammophilia Arenaria). The source and quality of the planting stock should be approved by the Contracting Officer or the authorized representative.
Digging, Stripping and Trimming:	The plants should be thoroughly cleaned by shaking sand and silt from the roots. Dead stalks and trash should be removed from the culms by stripping. The underground stems should be broken back so that one or two nodes remain. The grass culms should be sorted and tied into bundles weighing approximately 10 pounds; tops should be cut back so that the overall length of the planting stock measures about 20 inches.
Storage:	The planting stock should be planted within eight hours of removal from the nursery areas or heeling-in beds. The heeling-beds should be a well-drained damp trench with the roots (nodes) covered to a depth of at least eight inches. Stock should not be held in heeling-in beds for a period exceeding two weeks. The supply of stock at the planting site must be kept in a cool shady place or otherwise protected against damage from excessive drying. Cold storage at 34-38 degrees farenheit for periods of up to 2 months is also acceptable.
Transportation and Handling:	The planting stock should be handled and transported by any method that does not damage the planting stock or area.

Planting:

1. The grass is planted in hills with an average of three live culms per hill but no less than two in up to 10% of the hills.)

2. The spacing between hills should average 12 inches on the foreslope and 18 inches on the crest.

3. The grass should be planted to a depth of 12 inches, with sand or silt for cover compacted to exclude air from the roots (nodes). The top of the plant should be upright and extend approximatley eight inches above the ground.

4. No planting should be done on any area until the moisture is within three inches of the ground surface. Nor should any planting be done when the temperature exceeds 60 degress F. or when freezing conditions prevail.

5. All areas planted should be fertilized with coarse particle ammonium sulfate commercial fertilizer, applied at a rate of forty-two pounds of available nitrogen per acre (one pound per 1000 square feet). Fertilizer should be applied when the wind is calm and the rain is steady; irrigation may be substituted for rain. The fertilizer should be applied at the time directed by the Contracting Officer of the authorized representative.

Inspection:

1. Inspections should be made by the Contracting Officer or his authorized representative. A representative cross section of not less than 5% of the planted areas should be inspected to ensure compliance with the contract requirements.

2. Nonconformance with any specifications classifies a plant hill as unsatisfactorily planted. A tolerance of 5% or five unsatisfactory plant hills per 100 is satisfactory. However, any amount over 5% should be applied as an equal percentage reduction of the acreage planted (payments being made on the basis of net acreage). When the deficiencies are 10% or over, the contractor should be expected to take steps to correct them.

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[1] Specifications are also applicable to American beachgrass (Ammophila breviligulata) and Sea Lyme-grass (Elymus mollis).

Adapted from Ternyik, 1979

Secondary Stabilization

Plantings of secondary stabilizing vegetation are appropriate in well-vegetated backslope and back areas but not in the crest or foreslope.

The following plants are appropriate:

Salal (Gaultheria shallon)
Evergreen Huckleberry (Vaccinium ovatum)
Shore Pine (Pinus contorta)
Purple Beach Pea (Lathyrus japonicus)
Seashore Lupine (Lupinus littoralis)
Tree Lupine (Lupinus arboreas)

Secondary stabilization should be done in conformance with the recommendations provided in Table 2.

Secondary stabilization should only be done when initial stabilizing vegetation (i.e. European beachgrass) is well-established.

Method: Secondary plantings should occur directly in existing stands of beachgrass. Beachgrass should not be destroyed or removed prior to planting, so that it can continue to stabilize the area as secondary plants are establishing themselves. Succession should occur without destruction since beachgrass tends to thin out and die where it is cut off from sand accretion.

Crest Grading

Limited grading of sand from crest areas above the 26 foot elevation is allowed by this plan. These specifications should be followed carefully to minimize damage to dune vegetation and stability of the foredune. If done improperly grading can destroy stabilizing vegetation, cause unwanted sand accretion on adjacent lots and homes and substantially increase potential for ocean flood damage.

Timing:	Grading should only be done between November 1 and March 15. Windblown movement of sand at this time of the year is minimal.
Preconditions:	The crest area to be graded must be more than 4 feet above the 100 year flood elevation; in most of the Nedonna area this is the 26 foot elevation (MSL).
Equipment:	A bulldozer with size depending upon the extent of the area to be graded.
Method:	The area to be graded should be staked by an engineer in advance of grading so that the operator knows the limits on the area and the depth of grading to occur. Depth of cut should not exceed 4 feet. The management authority should be notified so that a representative can view the staked area, the grading operation and the completed grading. The bulldozer should be access through the jetty parking lot and travel along the beach. The bulldozer should avoid transiting across the foreslope. Low spots in the crest on the lot or adjacent lots (i.e. below the 26 foot elevation) are the priority location

for graded material. The management authority should identify spots on adjacent lots to be filled in its issuance of a grading permit. The cat operator's first passes should push sand to fill these low spots to the 26 foot elevation. (This will result in a crest 50-75' wide at a uniform 26' height, except in Subarea E where the crest is 100-125' wide.)

Where the adjacent lots are at the minimum elevation crest grading can be done in two ways:

(1) A series of short passes pushing sand directly oceanward from the crest to the foreslope.

(2) One or several passes along the crest of the foredune with the blade angled so that sand is deposited on the foreslope.

In either case sand should simply be pushed onto the foreslope. Where a substanital amount of sand is placed on the foreslope it should be smoothed out to create an even slope. If only a small amount of sand is graded forward the bulldozer should not attempt to smooth the sand forward on the foreslope.

Tapering: If the crest of adjacent ungraded lots is 4 feet higher than graded lots the grading should taper the crest into these areas rather than leave a right angle cut at the lot line.

Minimum Area: Grading should be done over several lots at a time to achieve a uniform crest height throughout. However grading may be done on a lot-by-lot basis provided all other specifications are met.

Fertilizing: Areas graded less than 3 feet should be promptly fertilized per the fertilization recommendations for Beachgrass plantings. Fertilizer should be applied to graded sand placed on the crest and foreslope as well.

Planting Beachgrass: Areas graded more than 3 feet in height should be replanted with European beachgrass at 18" spacing. Any graded crest area with less than 30% vegetative cover should also be replanted with European beachgrass.

Inspection: The Management Authority should inspect the site before and after grading to confirm that grading and other measures have been done in compliance with specifications here.

Permits for grading should be conditioned to require reestablishment of vegetation on all areas affected by grading or filling. The Management Authority should inspect the graded area at 1, 3, 6, 9 and 12 months after grading and recommend remedial measures at those times. Failure to comply should provide for Management Authority authorization to reestablish vegetation at the permittee's expense.

Foreslope Shaping

Foreslope shaping is appropriate in very limited situations to establish an even slope for maximum accretion of sand and foredune slope growth shaping should only be done when the present foreslope is so uneven and hummocky that it significantly impedes growth of the foredune.

Equipment: Lightest possible bulldozers should be used since less sand will be moved than for crest grading.

Slope:	Grading should attempt to establish an even slope at an angle between _____ to _____ degree slope (between 1 to 3 and 1 to 4) depending on the amount of sand available.
Distribution:	Unless sand is placed as a result of approved grading elsewhere shaping should only re-distribute sand presently on the foreslope. Only sand from the foreslope should be moved. Grading of sand from the crest or the beach onto the foreslope is regulated separately as grading or beach bulldozing and may be appropriate to provide sand for grading if there is a surplus of sand in these areas.
Minimum Area:	Shaping should occur over several lots at a time as shown on the grading plan map.
Tapering:	Shaped areas should be tapered into adjacent unshaped areas to avoid creating wind erosion or accretion problems.
Method:	Shaping should move as little sand as is possible to establish an even slope (i.e. top off hummocks). The operator should make as few passes as possible and should avoid damaging vegetation on the crest of the foredune.
Fertilization:	Vegetated areas that are not seriously damaged or buried more than 3 feet of sand should be immediately fertilized.
Plantings:	Unvegetated areas and areas covered by more than 3 feet of sand should be immediately replanted with European Beachgrass according to planting specifications.

Transplants Needed With Varied Spacing Requirements

Transplant Type	Spacing	1,000 sq. ft.	one acre
Beachgrass - 3 culms per hill	12"x12"	3,004	130,680
Beachgrass - 3 culms per hill	18"x18"	1,335	58,080
Beachgrass - 3 culms per hill	24"x24"	751	32,670
Beachgrass - 3 culms per hill	30"x30"	480	20,880
Beachgrass - 5 culms per hill	12"x12"	5,006	217,800
Woody species - 1 transparent per hill	3'x3'	111	5,840
Woody species - 1 transparent per hill	6'x6'	28	1,210
Woody species - 1 transparent per hill	8'x8'	16	680
Woody species - 1 transparent per hill	12"x12"	7	302

Note - A word of caution: Always order 3% more to offset heavy planting.

From Ternyik, Dune Stabilization Methods and Criteria, 1979

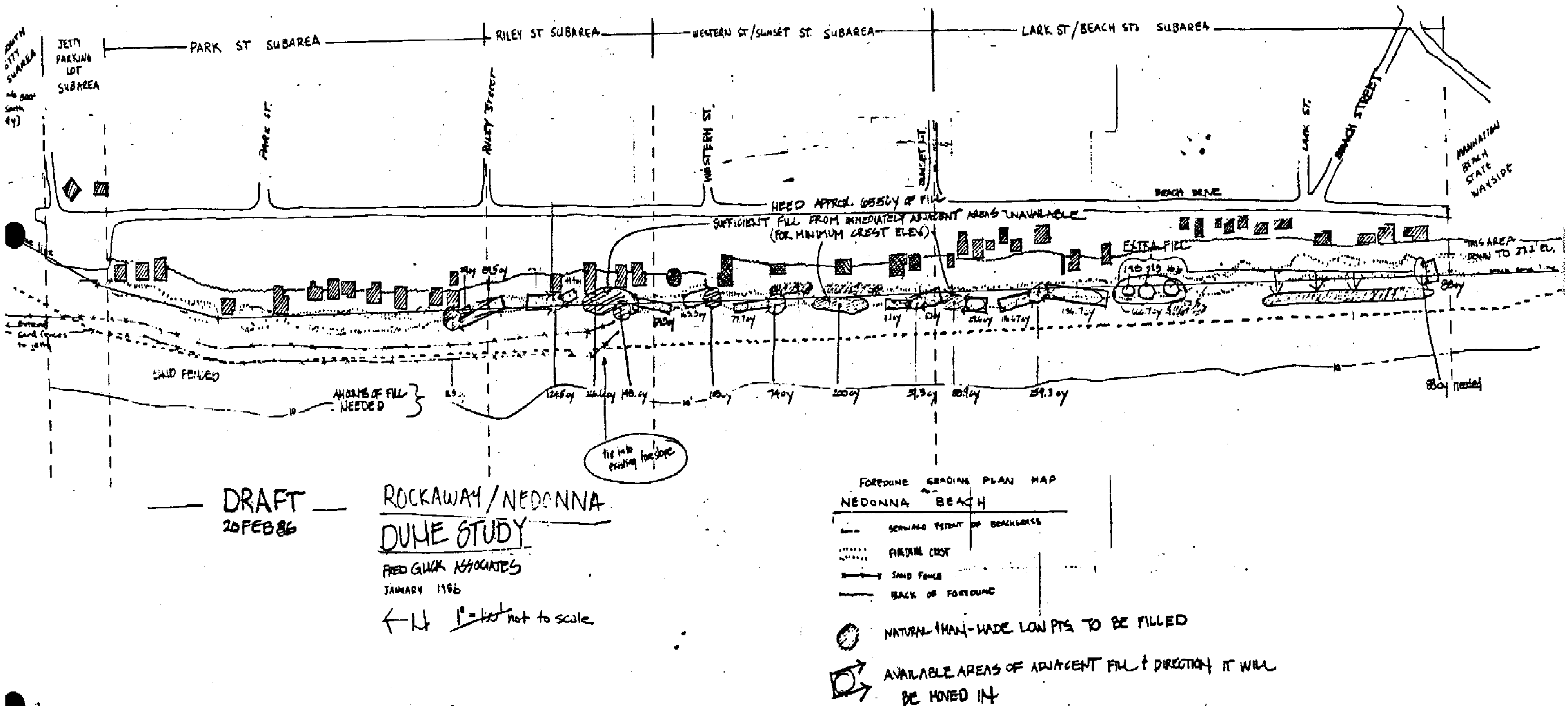
SECONDARY STABILIZATION

Recommended Native Plants for Dune Stablization

Species	C	S	BR	B&B	Seed	1-0	2-0	Size	CA	FC	SP	Season
European Beachgrass	X		X				X	20"	X		18"x18"	11/15 - 3/15
American Beachgrass	X		X				X	20"		X	18"x18"	11/15 - 4/15
Sea Lyme grass	X		X				X	20"		X	18"x18"	11/15 - 2/15
Seashore Bluegrass		X			X			15 lb.		X	cc	9 or 4 - 6
Seashore Lupine		X			X			7 lb.		X	cc	9 or 4 - 6
Purple Beach Pea		X			X			15 lb.		X	cc	4 - 6
Tree Lupine		X			X			30 lb.		X	cc	4 - 6
Salal		X		X			X	1 gal.	X		3'x3'	12 - 2
Evergreen Huckleberry		X		X			X	1 gal.	X		3'x3'	12 - 2
Scotch Broom		X	X			X		14 "		X	8'x8'	12 - 3
Shore Pine		X	X	X			X	12"-20"	X		8'x8'	12 - 2

C - Colônizer-initial stabilizer
S - Secondary-permanent S
BR - bare root stock
B&B - balled and burlapped
1-0 - one year old
2-0 - two year old
Size - height or pounds per acre
A-1 - foredune or frontal areas
A-2 - deflation plain or wet interdune
A-3 - open sand areas
A-4 - older stabilized dunes
CA - commercially available
FC - field collection
SP - spacing inches, feet, cc-complete cover
Season - planting dates (optimum)

Adapted from: Dune Stabilization Methods and Criteria, Wilbur Ternyik, 1979



JETTY PARKING LOT SUBAREA
PARK ST SUBAREA
RILEY ST SUBAREA
WESTERN ST/SUNSET ST. SUBAREA
LARK ST/BEACH ST. SUBAREA
PARK ST.
RILEY STREET
WESTERN ST.
SUNSET ST.
LARK ST.
BEACH STREET
BEACH DRIVE
MANHATTAN BEACH STATE WAYSIDE
NEED APPROX. 655cy OF FILL
SUFFICIENT FILL FROM IMMEDIATELY ADJACENT AREAS UNAVAILABLE (FOR MINIMUM CREST ELEV)
EXTRA FILL
THIS AREA DOWN TO 27.2 EL.
SAND FENCED
AMOUNTS OF FILL NEEDED
tie into existing foreslope
88cy needed
DRAFT
20FEB86
ROCKAWAY/NEDONNA
DUNE STUDY
FRED GLICK ASSOCIATES
JANUARY 1986
N
not to scale
FOREDUNE GRADING PLAN MAP
NEDONNA BEACH
SEAWARD EXTENT OF BEACHGRASS
FOREDUNE CREST
SAND FENCE
BACK OF FOREDUNE
NATURAL + MAN-MADE LOW PTS TO BE FILLED
AVAILABLE AREAS OF ADJACENT FILL + DIRECTION IT WILL BE MOVED IN

MANAGEMENT PLAN

ROCKAWAY/NEDONNA BEACH

BEACH AND DUNE MANAGEMENT PLAN

FOURTH DRAFT

15 FEBRUARY 1986

FOREDUNE ALTERATIONS

IMPACTS AND MANAGEMENT RECOMMENDATIONS

Appendices

A. Definitions

B. State Laws and Administrative Rules

- Statewide Planning Goal 18 (Land Conservation and Development)
- Ocean Shore Rules (Parks Division)
- Removal-Fill Rules (Division of State Lands)

C. Revetment/Rip-Rap Specifications

D. References

Introduction

In order to set the stage for this plan the nature of hazardous conditions at Rockaway and Nedonna Beach must be recognized. Similarly it must be understood that without a sound foredune management plan the risk of severe damage from ocean storms is greatly increased.

Man, since time began, has had a love affair with the sea and its beauty. However, as in other situations, love can obscure good sense about inherently dangerous situations. This is very apparent with most of the beach front homes and commercial buildings in the Nedonna Beach/ Rockaway area. With few exceptions, all structures were built on or near what is now classified as an unstable foredune. (These areas are subject to wave overtopping, ocean flooding, sand erosion and deposition.) One only needs consider historical erosion events to realize the gravity of the problem.

> In Tillamook County, logs were washed a block behind the oceanfront road at Manzanita. Nehalem faced its worst flooding since 1933 with nearly every business building in the main block being flooded. Waves carried logs over the sand dune and blocked the parking lot at the north end of Nedonna Beach, and damaged homes at Manhattan Beach. At Rockaway, the surge sent logs over the railroad tracks and onto U.S. Highway 101 damaging several houses, plugging the creek outlet and causing local flooding. Logs damaged houses at Twin Rocks and were carried accross the railroad tracks to the highway there. At Barview in Garibaldi, logs washed into Highway 101. Flooding occurred near the Miami River and some Highway flooding occurred near Tillamook. Logs were washed nearly two blocks back from the beach at Cape Meares, and logs damaged homes, seawalls, and riprap at Netarts. Picnic tables were washed away at the county park at Sandlake, and logs were strewn across the highway at Tierra Del Mar. Although many houses and buildings in Pacific City and Woods were surrounded by water, no damage was reported. At Camp Winema, logs were washed high above the beach, but no damage was done to the buildings; and at Neskowin, logs damaged beachfront houses.

Historically, one of the greatest ocean floodings in Tillamook and Clatsop Counties occurred on January 3, 1939, when high tides and windswept waters caused extensive damage over much of coastal Oregon. The sandspits at Bayocean and Neskowin Ridge were breached in several places and surf-swept logs damaged dozens of beachfront houses at Twin Rocks, Manhattan Beach, Tierra del Mar and other communities. South of Barview, 300 feet of Southern Pacific Railway track was carried inland over Highway 101. Waves splashed completely over Twin Rocks, one-half mile offshore from the community of Cape Meares. In calm weather, Twin Rocks and Pyramid Rock stand 80 and 100 feet, respectively, above mean sea level." (Environmental Geology of the Coastal Region of Tillamook and Clatsop Counties, Oregon, 1972, page 103).

In addition, several serious localized erosion events have taken place at different times, usually related to influence at creek outlet embayments or rip-current erosion points, In recent years, deterioration of the Nehalem South Jetty coupled with a rip-current caused severe erosion on the north end of Nedonna Beach in 1978.

Continuous patterns of erosion cycles described in the technical report and shown on Technical report maps clearly indicate continual wave erosion problems. In addition, the major storm erosion events of 1967 and 1939 indicate probability of future storm-induced erosion, flooding, and sand deposition damage in the future.

Given this set of facts, it is imperative that appropriate measures be taken as soon as possible to strengthen recognized natural storm wave defense systems. In numerous other parts of the world, there is a clear recognition of the protective nature of the foredune areas as a buffer zone against attack by sea. The U.S. Army Corps of Engineers reports:

"While the sloping beach and beach berm are the outer line of defense to absorb most of the wave energy, dunes are the last zone of defense in absorbing the energy of storm waves that overtop the berm. Although dunes erode during severe storms, they are often substantial enough to afford complete protection to the land behind them. Even when breached by waves of a severe storm, dunes may gradually rebuild naturally to provide protection during future storms. Continuing encroachment on the sea with manmade development has often taken place without proper regard for the protection provided by dunes. Large dune areas have been leveled to make way for real estate developments, or have been lowered to permit easy access to the beach. Where there is inadequate dune or similar protection against storm waves, the storm waters may wash over low lying land, moving or destroying everything in their path.

"Gently sloping shores, whether beaches or wetlands, are natural defenses against erosion. The slopes of the foredune form a first line of defense, dissipating the energy of breaking waves. The berm prevents normal high water from reaching the backshore. Dunes and their vegetation offer protection against storm-driven high water and also provide a reservoir of sand for rebuilding the beach. Wise management of shore areas should include protection of these natural defenses where they exist.

"Although erosion is essentially caused by natural shoreline processes, its rate and severity can be intensified by human activity. The shoreline and the water are highly valued for recreational activities, but heavy use and development may accelerate erosion. Those who build 'permanent' homes and recreation facilities often ignore the fact that the shoreline is being constantly built up and worn away again. They may also fail to take into account the periodic and unpredictable affects of storms." (Shore Protection Manual I, U.S. Army Corps of Engineers, 1975.)

In Europe, where some dune areas have been intensively managed for years, foredunes referred to as barrier dunes are given prime consideration because of their protective nature.

"On sandy coasts, the ridges of sand dunes are often the natural protective structures against flooding the low-lying land, the villages or towns during storm tides. The strength and resistance of these barrier dunes, which are found just landward of the beach, is to be estimated in consideration of the extent and the height of the dunes as well as of the width, the height and the stability of the beach. As in many cases on the beach in consequence of altering sea and wave conditions and different littoral drift, the supposition for erosion or aggradation varies, dunes and beaches have to be observed constantly. The beginning of a considerable erosion of the dunes has to be seen in connection with the development of the beach. A systematical research of the reasons and the further development has to be done. The research has to include the total dune-beach-profile." (Erchinger, Heie. Protection of Sandy Coasts in 1974. Dependence of the Dune-Beach-Type)

In the section of West Germany referred to above, annual erosion of foredune foreslopes is repaired each season. This same abstract by Erchinger speaks to repair of eroded foreslope in the Netherlands on the Isle of Tuxel by use of bulldozers, then replanting. Only on the West Coast of the United States do plans ignore or discourage foredune modification or restoration. However, on the East Coast and in Europe, total management plans are developed, rigid ordinances and rules protect the natural and enhanced protective nature of the foredunes.

Through grading the foredune for ocean viewing caused this tudy to take place, the ultimate more valuable result will be strengthening the protective nature of the foredune by informed management.

The beach and foredune are critical to protecting backshore areas from ocean flooding. Even so, foredunes are fragile landforms, easily damaged or destroyed by human use or development. Extensive residential development along the Rockaway Beach/Nedonna Beach shoreline and associated activities and uses there have altered the shape and size of the foredune. The result is that the foredune's flood protection ability has been reduced.

This report assesses the effects of most of the uses and activities which either have or could affect the stability of the foredune at Rockaway Beach and Nedonna Beach. The report recommends limits on how, when and where these activities should be conducted to minimize possible harm to the foredune.

The report's recommendations will need to be carried out by local governments, state agencies and property owners. Tillamook County and the City of Rockaway Beach play a major role through their review of permits for building and development. The State Parks Division and the Division of State Lands should implement relevant recommendations through their permits for beachfront development and alterations. Finally, property owners have a critical role to play since many recommendations deal with the day-to-day use of the foredune, such as beach access and maintenance of beachgrass.

If this report's recommendations are carried out, then the foredune should be strengthed and the potential for flood damage reduced. This will be done by improving the ability of natural processes to build and maintain the foredune. However, it must be stressed that these measures will not guarantee freedom from ocean flooding or erosion. Foredunes are inherently unstable areas and the dynamics of ocean flooding and erosion in foredunes are simply too unpredictable to guarantee that ocean flooding or damage will not occur. The recommended measures will simply do what is possible to enhance the natural protection provided by the foredune. The potential for catastrophic flooding and damage should be an understood risk of owning oceanfront property.

Importance Of The Foredune

Maintenance and enhancement of the foredune and natural beach-dune processes is critical because of the protection this system provides against ocean flooding. If the foredune is damaged or the natural system disrupted, the potential for ocean flood and erosion damage to oceanfront development is increased. The beach and foredune respond to ocean flooding in a predictable way:

> "As the dune is attacked by storm waves, eroded material is carried out and deposited offshore, where it alters the underwater configuration of the beach. Accumulating sand decreases the offshore beach slope (makes it more nearly horizontal), thereby presenting a broader bottom surface to storm wave action. This surface absorbs or dissipates through friction an increasingly large amount of destructive wave energy that would otherwise be focused on the shoreline behind the barrier.
>
> The capacity of the dune for absorbing and moderating wave energy is not dependent on any ability to completely prevent breaching or flooding. Even in the process of being inundated and destroyed, as many are by hurricanes, the dune moderates back beach storm damage. The effect is less pronounced for low dunes, but nevertheless persists. Since storm resistance increases with dune height, however, all human uses of the barrier that devegetate, erode, or lower the dune expose the shoreline behind the barrier to increased storm damage." (Clark, 1977, 267).

bulk - the more sand in a foredune the more wave energy will be required to penetrate the dune.

height - A higher dune can withstand overtopping or breaching that would flood back areas.

shape - A smooth low sloping foreslope will direct waves up the dune dissipating some of the wave energy. If the foreslope is steep or vertical, more erosion will occur.

vegetation- A well vegetated foredune will hold together better in the face of attacking waves. Unvegetated sand will break up more quickly by waves.

location - A foredune fronted by a wide beach will receive less wave attack compared to a foredune or a narrow beach.

Managing and enhancing the foredune to provide flood protection is not a new technique. In Europe, foredunes, or barrier dunes, have been managed for years to provide flood protection for inland area.

> "The Dutch rely on the natural sand dunes as their primary (or outer) defense against the sea, and on dikes, which are actually substitute dunes, for their secondary or inner defense ring. The manner of construction and maintenance of these defenses is such as to ensure their natural state, which is sufficiently flexible and resilient to absorb all but the severest forces of wind and waves.
>
> The key to Dutch success in maintaining their coastal protection lies in the management of their dune and dike system. Although intensive recreational usage is permitted on the beach, absolutely no passage, breaching, or building on the dunes is permitted. Limited recreation and building are permitted in the trough between the primary and the secondary dune (or dike). The backdune area is recognized as the most suitable for development. This strategy of encouraging the coastline to persist in its natural

> state serves to maintain the optimum protection afforded by nature." (Joseph M. Colonell, in Clark, 1977, p. 571)

Similarly in West Germany the foredune has been managed to provide flood protection. In both cases much more information about the dune and nearshore bar is available. For example, foredunes in some areas have been managed for over three hundred years while in other areas the offshore bars have been monitored and structurally diverted to enhance beach stability.

APPLICABILITY TO OTHER AREAS

While this study has focused on the Nedonna Beach/Rockaway Beach shoreline many of the managment recommendations can be applied to other developed foredunes on the Oregon Coast. (These recommendations should be limited to foredunes where extensive development has already occurred. Through Statewide Planning Goal 18 Oregon has prohibited building on undeveloped foredunes because of the inherent instability of these areas and the potential for ocean flooding. This prohibition is appropriate and should continue.)

Overall, management of foredune alterations should be viewed as necessary in developed foredunes. Whether well advised or not foredunes have been developed for long-term residential use. In turn the state, through its coastal planning requirements has allowed building on developed foredunes to continue. The management philosophy in these areas now should be to provide as much protection as is possible without interfering with natural processes or harming adjacent areas. The management recommendations provided here implement this philosophy: Activities which would harm the foredune or interfere with natural accretion or erosion of sand will be controlled; steps to strengthen the foredune's ability to capture and stabilize sand and withstand flooding will be encouraged.

The same philosophy and recommendations are generally applicable to other developed foredune areas. However, there are clearly some limitations to applying these recommendations to other developed foredune areas. Before applying these recommendations in other areas local governments and relevant state agencies should consider and evaluate the following factors:

The Rockaway-Nedonna Beach shoreline is extensively developed and does not appear to be subject to long-term erosion at this time. If the shoreline was receding and were less developed, prohibition of further development and relocation of homes would be an appropriate alternative.

While there are many steps individual property owners can take to strengthen the dune any major alterations such as grading must be conducted as part of an areawide plan, supported by appropriate technical analysis. Major alterations for arbitrarily small streches of shoreline can easily ignore nearby features which could undermine the foredune (such as a major breach) and are inappropriate.

The measures recommended in this report, while appropriate to most developed foredune areas, are based on the particular circumstances in Rockaway and Nedonna Beach. Peculiarities of other areas should be considered through professional review prior to applying these recommendations. For example, erosion at the Alsea and Necanicum River Spits over the last year demonstrates the special hazard of development on foredunes near unstabilized river mouths.

Crest grading is appropriate only where foredunes are well established:

- where the foredune is developed and the shoreline demonstrates long-term stability with no known reduction in shoreline sand supply.

- where the foredune is well vegetated

- where, per Goal 18, the foredune is mostly more than 4 feet above the 100-year flood level

SHORELINE STABILIZATION

The major effect of human development along the ocean shore is to attempt to establish and maintain the shoreline at a particular location. A variety of structures have been constructed to promote accretion and prevent erosion so as to maintain a particular shoreline. Two types of structures have been critical to protecting the shoreline in the study area -- jetties at Nehalem and Tillamook Bays and, to a much lesser extent, rip-rap or revetments in front of several oceanfront homes, buildings and roads. This section assesses the impacts of these "improvements."

Jetties

The Nehalem Bay jetties on the North and, to a lesser extent, the Tillamook Bay jetties on the South have had a profound effect on the shoreline in the study area. Jetties are placed to stabilize a river mouth at a particular location as it enters the ocean. Without jetties, river mouths tend to migrate in response to littoral movement of sand and sandbars along shore.

The rehabilitated Nehalem Bay jetties have in concert with the 1982-83 El Nino resulted in substantial accretion at the south jetty. (There was about 150 feet of accretion to the beach from 1978 to 1984). The original jetties experienced serious degradation within twenty years of their construction. (Corps of Engineers, Jetty EIS, 1980 p. 1-1). The Corps expects the rehabilitated jetties to be effective for at least 50 years since they are better constructed with harder rock and a more substantial core. Nonetheless, the condition of the jetties should be monitered.

Maintenance of the jetties is permitted under the Statewide Planning Goals, the County's Comprehensive Plan, and the State Removal-Fill Law. It should be noted that future maintenance of the jetties is not guaranteed. The recent rehabilitation was done as a result of special congressional appropriation. Changes in federal policy on funding navigation improvements, will probably require local cost-sharing which may make future maintenance of the jetty an expensive if not uneconomical proposition.

Management Recommendations:

1. The Nehalem Bay jetties, and the South Jetty in particular, should be maintained in order to keep the shoreline at Nedonna Beach at or near its present location.

2. The Corps of Engineers and the Port of Nehalem should periodically monitor the condition of the jetties. Additional research is needed to assess changes in the adjacent shoreline, and nearshore sand bars and to evaluate the effect of the jetties in blocking littoral sand movement.

3. The undeveloped shoreland area behind the jetties is dependent on the continued maintenance of the jetties and should not be developed unless a guarantee is provided that the jetties will be maintained for the life of the development.

Shorefront Protection Structures

Shoreline erosion is a recurring problem in the study area. Rip-currents, El Nino events, and severe ocean storms have caused erosion which has threatened oceanfront homes. In addition, experience in other areas and the projected 100-year storm suggest that the shoreline throughout the study area will be subject to erosion. The most likely erosion events will be periodic episodes of erosion which affect short stretches (200' to 1000') of shoreline (Komar). Such erosion is likely to occur at rip-current embayments during winter storms. However, major erosion is still possible throughout the study area as part of a major prolonged ocean storm event. (Such as the January 1939 storm which had a recurrence interval of 75 years.)

While the beach and foredune provide some protection their grade and mass may not be completely sufficient to protect existing development from damage. Where the natural system is inadequate some form of structural protection will be needed to protect exsisting development. Unfortunately, the need for protective structures for particular areas will only be apparent when development is threatened by an ongoing or imminent erosion episode. For example, much of north Nedonna Beach was rip-rapped in 1978 when a series of storms eroded the shoreline there that coincided with a beach narrowed by rip currents.

Structural shoreline stabilization can include a variety of constructed improvements or alterations intended to fix the shoreline at a particular location (i.e, to prevent further landward movement of the beach). Stabilization is usually done to protect existing homes from on-going or imminent ocean wave erosion. Nationally, a wide variety of devices placed on the shoreline, on the beach or in the nearshore ocean are used to stabilize the shore. The most common means of stabilization on the Oregon Coast are revetments made of large stone (aka rip-rap). The State has adopted several laws and rules which limit the construction of shoreline stabilization structures and devices because of the adverse effects that they can have on the beach and neighboring properties.

Effects of Shoreline Stabilization Structures

This discussion only addresses structures constructed at or landward of the shoreline since these are the only types commonly used or allowed in Oregon. Structures located on the beach or in the water, such as groins and breakwaters, are generally considered inappropriate for this shoreline and inconsistent with the management of objective of preserving the natural shoreline processes as much as possible.

The purpose of most stabilization structures is to prevent ocean wave erosion of the shoreline. Properly located and constructed structures have this effect. They can also have several other important effects on the beach and the sand supply system. Structures placed on the shoreline include seawalls, or bulkheads, as well as revetments. Bulkheads and seawalls have some common effects on beach sand supply. The most immediate of these is that the foredune behind the wall is cut off as a source of sand to the beach. If a large stretch of shoreline is armored the effect is to reduce the supply of sand available to the beach and for accretion to nearby areas.

The ocean wave energy that would be absorbed through dune erosion is instead partly absorbed and partly reflected off of the shoreline structure. Reflected wave energy increases beach erosion. Unfortunately, seawalls (including bulkheads and revetments) commonly accelerate the loss of sand as the wall deflects wave forces downward into the beach deposit. This causes the sand to erode away seaward of the footing and the beach to dimish or dissappear. Often the seawall is undermined and collapses. (Clark, 1977, p. 323). Over-time these two effects--cutting off sand supply and reflecting wave energy to the beach--can cause dramatic erosion of the beach.

The extent of beach loss over time is difficult to predict. Experience at other shorelines around the country and the world suggest, such structures are an important factor in loss of beaches. In many areas much more expensive solutions, such as ongoing beach nourishment, have been required to offset the effects of erosion.

The effect of particular types of structures varies. Vertical seawalls and bulkheads reflect most of the wave energy back onto the beach perpendicular to the structure. Properly sloped riprap revetments also deflect some wave energy upward rather than back onto the beach.

Structural solutions should only be employed when it is clear that natural processes will not provide adequate protection, and that alterations should be the minimum necessary to correct the problem.

> "...extensive areas of the coast are already occupied and must somehow be maintained safely until setbacks and

other protective land-use plans can be implemented. Yet even these systems should be allowed to remain as close to their natural dynamic states as possible." (Clark, 1977, 323)

"The natural forces at work are immense, and the power of man to hold the beach at the higher than natural angle of repose to protect property is limited. Structural solutions are often ineffective and usually only temporary.

There are two possible solutions that should be considered together. First, permanent development should be placed well inland of the active part of the shore, including receding shores that would be expected to become active in the future. Second, positive action should be taken both to prevent the removal of sand from any storage element and to prevent blocking the free transport of sand from any one storage element into the active part of the system." (Clark, 1977, 322).

Oregon has adopted three major sets of laws and rules controlling or prohibiting shoreline protective structures. They include:

- The Ocean Shores Law, commonly known as the Beach Bill (ORS 390.605-390.770). It sets in statute a public easement to the beach up to the high tide line. Any interference with this public easement is subject to state regulation. Placement of structures requires permits from the State Parks Division which administers this law.

- The Removal-Fill Law (ORS 541.605-.695, 541.990), regulates removal or filling within the bed and banks of waters of the state. On the ocean beach this authority extends to the upland vegetation line. Filling includes placement of shorefront protective structures.

- Statewide Planning Goals 17 and 18 (the Coastal Shorelands Goal and the Beaches and Dunes Goal, respectively) set specific planning requirements for siting of shoreline protective structures.

Goal 18 prohibits beachfront protective structures in areas that were not built or physically improved for development on January 1, 1977. Specifically, it requires:

> "(5) Permits for beachfront protective structures shall be issued only where development existed on January 1, 1977. Local comprehensive plans shall identify areas where development existed on January 1, 1977. For the purposes of this requirement and implementation Requirement 7 'development' means houses, commercial and industrial buildings, and vacant subdivision lots which are physically improved through construction of streets and provision of utilities to the lot and includes aras where an exception to (2) above has been approved."

With only a few exceptions, most of the shoreline in the study area is qualified for revetments under Goal 18 when such structures are shown to be needed.

The remaining requirements of Goal 18 along with Goal 17, the Removal-Fill Law, and the Beach Bill control how and where shoreline structures can be constructed. Both DSL and ODOT require permits for most shoreline structures. DSL's jurisdiction extends to mean higher high water (mhhw) or the vegetation line, whichever is higher. ODOT permits are required for structures located seaward of the surveyed beach zone line. The Statewide Goal requirements are applied either by these agencies during their review or through a separate local review. The specific requirements of these laws and rules are provided in Appendix __.

These requirements limit shoreline protection to areas which were developed on January 1, 1977 when they are threatened and then only where no other method of erosion control will work. In addition, protective measures must be properly installed and adequate to protect the property without causing increased erosion or flooding on adjacent properties. These requirements provide for the right of upland property owners to protect their homes or property while minimizing adverse impacts of such structures on adjacent properties and the public beach.

The tendency of revetments to increase erosion on surrounding unprotected properties is an important consideration in deciding at what point a foredune should be riprapped. Generally, erosion events attack a stretch of shoreline uniformly--a group of lots will all experience roughly the same amount of erosion. In these situations riprap should be placed in a continuous line parallel to the retreating foredune. This way the structure does not deflect wave energy to adjacent lots.

Management Recommendations

1. Because of cost and potential effects on shoreline stability and adjacent properties structural shoreline protection should only be permitted when erosion clearly threatens existing development.

2. Revetments should be located as far landward (i.e., close to existing dwellings) as possible in order to avoid unnecessary construction of structures and to minimize interference with natural sand movement as part of the erosion and accretion process.

3. At this time riprap appears to be the only appropriate means of structural shoreline protection in the study area. Breakwaters and groins are inappropriate because they interfere with natural movement of sand along the beach and in nearshore bars. Seawalls or bulkheads are generally inappropriate because they may reflect wave energy promoting beach erosion inconsistent with the objectives of this

plan. Riprap is appropriate because, where it is properly designed and constructed, it provides shoreline protecion with minimum disruption to natural processes.

4. Revetments shall be designed and constructed to meet at least the minimum specifications set forth in Appendix C.

BEACH/DUNE ALTERATION

Beaches and dunes have been intentionally reshaped or altered by man for a variety of purposes. In some areas of the coast, beach sand has been excavated for construction material or fill. The most common alteration in the Nedonna-Rockaway area has been grading of the foredune. Crest grading has been done for a variety of purposes including site preparation, view maintenance and to remove sand build-up around structures. Other alterations that can or have occurred include: sand placement, dune breaching, beach pushing, and beach nourishment.

> "In most cases, removal or serious alteration to the protective foredune will mean that substantial sand deposition damage will result to man's existing developments and public works, lakes, wildlife areas, agricultural land and forests. In other words, the active foredunes or those foredunes conditionally stable provide a protective wind barrier to what exists landward of them and the removal of the barrier will increase wind erosion and sand deposition in the landward area." (Soil Conservation Service, Beaches and Dunes of the Oregon Coast, p. 137).

While foredune alteration is discouraged it is clear that some alterations can be done without destabilizing the foredune. In fact, some of the foredune is in such poor condition that additional alteration is needed to strengthen it. For example, the foredune in several parts of the study area is low, narrow or discontinuous. These parts of the foredune provide an uneven barrier to windblown sand and ocean flooding. Measures to increase the foredunes base width, foreslope angle and vegetative cover are appropriate in such areas. However specific corrective measures should only be done as part of a management plan for a larger area.

Alterations to beaches and dunes are regulated at the local, state and the federal level. Tillamook County and the City of Rockaway Beach administer zoning and building requirements which implement local requirements. These local permits are also used to carry out state planning requirements (LCDC Goals) and federal floodplain management requirements. The Parks Division regulates any alteration oceanward of the surveyed beach zone line. The Division of State Lands exercises the state's jurisdiction over beds and banks of public waters through the Removal-Fill law, which covers up to the line of nonaquatic vegetation or the highest high tide. Finally, the Army Corps of Engineers has federal jurisdiction comparable to that exercised by DSL.

Foredune Grading

As noted above, foredune grading is the most common alteration to the foredune in the study area. Grading of foredune crest at Nedonna Beach has been done to maintain ocean views of oceanfront homes. With few exceptions grading has not seriously damaged the integrity of the foredune. Damage from grading has been limited for several reasons:

- usually only a small amount of sand is moved, the top 1-3 feet of the foredune is graded; the resulting foredune height is typically 1-2 feet above the 100 year flood level.

- sand is pushed forward onto the foreslope rather than pushed back or removed altogether;

- stabilizing vegetation (beachgrass) while damaged is not destroyed or removed, allowing it to reestablish and restabilize the lowered foredune; and,

- grading seems to have been done at times of the year when wind transport of sand has been limited.

In some places, particularly the northern portions of Nedonna Beach, grading and other alterations have either destroyed the foredune or prevented it from becoming well established. The pattern of alteration appears to have been more serious in these cases:

- deeper cuts (i.e., more than 3 feet) have been made in the foredune.

- vegetation has been destroyed or reduced to the point that significant amounts of sand are blown inland rather than captured in the foredune.

- grading has been done frequently so that vegetation has not been able to re-establish the foredune.

The foredune at north Nedonna Beach is lower and narrower than the area to the south for two other reasons. First, a 1500' area here experienced severe erosion requiring riprap in 1978. The area has not fully recovered (recovery has also been hampered by improper grading). Second, the foredune next to the jetty parking lot has been breached by emergency vehicle access across the foredune.

The most serious effect of grading in Nedonna Beach is increased potential for floodwater overwash in places where the foredune has been lowered to or below the 100-year flood level. The predicted heights for 100-year flooding in the Nedonna Beach area is 22 feet (HUD, Flood Insurance Rate Map, 1978) while crest heights run from 17 to 30 feet, with several graded sites at or below the 100-year flood level. Lowering of dunes has created an opportunity for storm waves to overtop the foredune resulting in more extensive flooding.

Not all grading increases potential flood damage. In fact some reshaping and movement of sand may actually increase overall protection from flooding (up to the 100-year flood level). For example, the northern portion of Nedonna Beach is characterized by a discontinuous foredune and hummocks, both of varying width and height. The hummocks are probably less effective than a uniform vegetated slope in blocking windblown sand and dissipating ocean wave energy. Foredune management including grading, shaping, and revegetation would increase protection. The establishment of optimum orientation, slope and guan vegetative cover will lead to self maintaining foredune.

Foredune grading is conditionally allowed by Statewide Planning Goal 18 (Beaches and Dunes). Grading is also regulated by local floodplain ordinances and requires permits from DSL or Parks if the beach is affected by grading. Goal 18 requires a management plan for a beach and dune area to show the feasibility of grading and set limits on how and where grading may occur. Specifically, the Goal requires:

> "Grading or sand movement necessary to maintain views or to prevent sand inundation may be allowed for structures in foredune areas only if the area is committed to development and only as part of an overall plan for managing foredune grading. A foredune grading plan shall include the following elements based on consideration of factors affecting the stability of the shoreline to be managed including sources of sand, ocean flooding, and patterns of accretion and erosion (including wind erosion), and effects of beachfront protective structures and jetties. The plan shall:
>
> a. Cover an entire beach and foredune area separated from other areas by natural barriers, such as rivers or large streams. Such plans should also cover low-lying back areas subject to flooding if the foredune fails.
>
> b. Specify minimum foredune base, width, foreslope angle, crest width and height goals. The minimum height for flood protection under Statewide Planning Goal 18 is 4 feet above the 100-year flood elevation;
>
> c. Identify and set priorities for low and narrow dune areas which need to be built up;

d. Prescribe standards for redistribution of sand and temporary and permanent stabilization measures including the timing of these activities; and

e. Prohibit removal of sand from the beach-foredune system."

This plan and the recommendations provided below are intended to implement and satisfy these requirements.

Several factors led LCDC to require that foredunes be maintained at an elevation higher than the 100-year flood level. Basically LCDC stipulated a higher elevation to account for uncertainty in the methodology in calculating flood heights and to provide an additional safety factor against potential flood damage. FEMA and FIA 100-year velocity ocean flooding levels are a statistical estimate. FEMA (formerly FIA) use historic ocean storm conditions, tidal information, and tsunami information to calculate an ocean storm which has a 1% chance of occurring in any given year. This is a 100-year storm or flood event. It is the basis for mapping floodplains and regulating floodplain development throughout the country. However, there are several limitations to using this elevation as a minimum height for foredune elevation:

1. The methodology does not appear to account for foredune erosion, especially during storm events. FEMA's projections of ocean flooding for particular areas are based on offshore and nearshore bathymetry and onshore topography. This information is used to calculate wave direction and wave run up patterns on the beach, and ultimately the height of ocean flooding on a particular stretch of beach. The calculations assume that the slope and elevation of offshore and onshore features are relatively fixed. FEMA does not appear to take into consideration changes in the offshore underwater sandbars protective nature in dissipating wave energy. The changes or migration of sandbars has not been mapped here or anywhere else on

the Oregon Coast. The importance of these underwater sandbars should be appreciated: They provide the first line of defense against sea waves and provide a continuous sand supply to the beach system. While this is true for more resistant landforms, like terrace cliffs or basalt shorelines, it is not true for dunes. Over time, dunes accrete and erode in ways that alter flooding patterns and to some extent may alter flood heights. Foredunes also erode away as they absorb the energy of ocean storm waves striking them. The result is that some of a series of waves occurring during a 100-year storm may penetrate beyond the 100-year velocity flooding areas mapped.

2. Floodwaters projected by FEMA will top the 100-year velocity flood level. FEMA draws the limit of velocity flooding at the elevation where it calculates that waves are breaking one foot above the crest of the foredune. In these shallow flooding areas there is still wave damage and erosion, although wave energy is much reduced.

3. FEMA's methodology for calculating flood levels in oceanfront areas is less accurate than in riverine situations. 100-year flood projections for riverine areas are based on much better information about factors affecting flooding. Rainfall, basin capacity, and other factors determining flood heights are much more accurately measured. Offshore bathymetry changes over time and is not as accurately measured as river channels. Also the magnitude of potential storm events (and the factors that cause them) are not as well understood in ocean settings. The result is there is less confidence in FEMA's estimates of ocean flood heights.

4. Recent flood events suggest FEMA has underestimated the severity of the 100-year flood event.

   FEMA's calculation of the 100-year flood event implies a certain likelihood of lesser flood events (i.e. 10 and 50-year storms). Researchers advising LCDC observed that the frequency of severe storms and flooding over the last 10-15 years suggest the 100-year event is more severe than that estimated by FEMA.

These considerations were discussed with FEMA regional staff and the authors of FEMA's flood study for the Rockaway and Nedonna areas prior to establishing the four foot plus elevation. Overall, LCDC concluded that some additional height should be added to provide a safety factor. LCDC's selection of four feet was influenced by the fact that levee structures are typically built two to four feet above expected flood levels.

Several property owners and others have questioned the four foot plus figure selected by LCDC. Further study of ocean flooding in foredune areas is needed. As noted previously, dune height is one of several factors which determine the foredunes ability to withstand flooding. Maximum flood protection requires a foredune with a wide base, and a gentle foreslope, as well as a particular height. The Commission can consider any new evidence on these factors when it reviews application of this goal requirement in 1987.

Management Recommendations

1. Limited grading of dune crests which are more than four feet above the 100-year flood elevation is appropriate and permissible under Statewide Planning Goal 18. Excavation of lower portions of the foredune is not permitted by the goal. Grading may not lower the foredune crest below the 100-year flood plus four foot elevation (per Statewide Planning Goal 18). Applications for grading permits should show existing and proposed elevations including the area for placement of graded sand and the existing and proposed slopes.

2. Limited surface grading of some foreslope areas should be done to encourage growth of a foredune that is more uniform in height and width and thus more effective at both stabilizing windblown sand and withstanding ocean flooding and wave erosion. This type of grading is appropriate where the foreslope is characterized by a series of hummocks or small discontinuous dune ridges. Grading of foreslopes

should be carefully blended into adjacent foreslope and crest areas. Also grading should only reshape the foreslope. (This action may require ODOT or DSL permits.)

3. Grading of foreslope areas should only be allowed when c has sufficient vegetation to prevent sand intrusion to back areas.

4. Sand graded from foredune crests should be placed according to the following priority, from highest to lowest:

   a. in low spots in the crest area of the foredune on the lot and adjacent lots;

   b. in low spots in the foreslope of the lot, when placement results in a foreslope of more uniform height, smoothness, and slope;

   c. in foreslope areas on adjacent lots to increase dune volume;

   d. Surface grading of hummocks on the foreslope should be done to provide an even foreslope to promote even accretion of sand. (This will require revegetation to assure even growth.)

   Material should only be placed in a lower priority location if a higher priority location is not available. No graded material should be placed landward of the crest.

5. The area and amount of grading need to be strictly limited so that large areas of the dune are not destabilized at one time. An areawide grading plan for Nedonna Beach specifies where and how grading may occur.

6. Graded areas must be promptly restabilized by appropriate measures including temporary stabilization, fertilization and planting of European beachgrass.

7. FEMA should review its methodology for calculating ocean flood elevations in general and the response of foredunes to ocean flooding in particular. This should include reassessment of potential flood elevations in the study area on a regular basis. LCDC should consider this information when it evaluates the Goal provision for foredune grading.

Foredune Breaching

Foredune breaching is the intentional or unintentional creation of a gap in a foredune. Breaching is usually done on a temporary basis in an emergency situation such as to allow floodwaters to escape from backdune or inland areas or to conduct salvage operations on the beach. Breaches allow sand which would otherwise be captured in the foredune to be blown inland. Inland structures can be damaged or inundated by inland movement of sand through a breach. Breaching can occur inadvertently when a foredune is graded or when a revetment is installed. In either case, the effect of a breach is to allow windblown sand or floodwater that would otherwise be blocked by the foredune to pass through.

Temporary breaching of the foredune to allow backed up floodwaters to escape from inland areas has been effective. When the foredune is promptly restored this type of breaching appears to have minimal effect on foredune stability. Statewide Planning Goal 18 (Implementation Requirement 6) allows temporary breaches in emergency situations such as relief of backed up floodwater. Goal 18 also allows foredune breaching for replenishment of sand supply to interdune areas. This provision was intended for parts of the Coast with undeveloped foredunes fronting large open large dune fields such as those at the Oregon Dunes National Recreation Area. However, such dunes do not exist in or near the study area. Breaching for this purpose in the study area would reduce sand supply in the beach and foredune which is needed to protect existing development from ocean flooding.

Management Recommendations

1. Breaching should only be permitted where it is necessary to alleviate a clear and immediate emergency situation, such as drainage of flood waters from low-lying back dune areas or for salvage operations.

2. Breaching should only be allowed if it is clear that it is not reasonable to alleviate the emergency in some other way. For example, directing floodwaters through an existing stream outlet.

3. Where breaches are permitted or occur illegally the person or organization causing the breach shall take steps to assure that minimal erosion to the beach and dune occurs as part of the breach, including: (1) temporary placement of riprap in the breach, if necessary; and (2) and that the breach is restored to its pre-existing contours including planting of vegetation as soon as feasible after the breach has occurred but no later than ten months after the breach has been accomplished. Temporary stabilization measures, such as the placement of straw mats or sand fences, shall be taken if the area is considered subject to erosion prior to the planting season for beach grass.

4. Breaching of foredunes to provide sand supply in interdune areas is clearly inappropriate in the Rockaway-Nedonna Beach area. The sand is needed on the beach or in the foredune to protect existing development. Inland movement of sand would be damaging to existing structures.

Beach Nourishment

Although it has not been used on the Oregon Coast beach nourishment is an accepted practice elsewhere in the world, especially on receding coastlines. Basically beach nourishment compensates for beach erosion by adding new sand to the beach-dune-nearshore system. The effect of adding new sand is obvious:

"...if the supply [of sand] is somehow enhanced, the beach will widen (i.e., accrete) until equilibrium is established once again. (Colonell, in Clark, 1977 p.)

Artifical enhancement or beach nourishment is tremendously expensive ($50 to $400 per foot) and requires frequent maintenance (at 1 to 5 year intervals). (Clark, 1977, p. 331). Also sand must be imported from outside the beach-dune-nearshore system to result in a net increase in the size of the beach. Removal from another part of the beach-foredune system will not enhance protection:

An erosion problem should not be solved by bringing sand from some other part of the same beach. [T]here are two appropriate sources of supply for beach nourishment: (1) the open ocean or broad nonestuarine bays beyond a depth of about 40 feet (14 meters), or (2) around inlets or other areas of accretion, where the supply is constantly replenished by natural forces, particularly when navigation dredging is being done." (Clark, 1977, 329).

While periodic navigation dredging occurs at the mouth of Tillamook Bay (and is proposed for Nehalem Bay) no disposal has occurred in the beach-dune-nearshore system. Beach nourishment was proposed by Stembridge in 1978 but was rejected because of concerns of resource agencies that sand deposited in nearshore waters would smother nearshore biological communities. Consequently, dredged material is instead disposed further offshore (i.e., beyond the nearshore system) or on upland sites.

Management Recommendations

The Corps of Engineers should re-evaluate nearshore or beach disposal of dredged material to determine if beach nourishment can be accomplished in an environmentally acceptable manner. This should include an assessment of sediment suitability (i.e. sand grain size) and alternative disposal techniques.

Beach Pushing

Beach pushing involves bulldozing large amounts of sand from the lower beach onto or toward the foredune. Beach pushing has been used in other states to rehabilitate eroded beaches and foredunes. Experience in North Carolina concludes that there is no detailed scientific evidence on the effectiveness of beach pushing, that it may increase storm damage if done on a large scale, that it may have the same effect as a bulkhead if done continuously, and that benefits are short term at best. (North Carolina, Coastal Resource Commission, Outer Banks Erosion Task Force, July 1984, pp. 11-12). While the North Carolina Coast is substantially different from Oregon's the concerns about beach pushing there deserve consideration.

Bulldozing of beach sand has been done on a very limited basis in Oregon. One-time "shaving" has been allowed to provide fill to properly slope eroded banks for installation of revetments at Kla-ha-nie Shores in Lane County in 1983. Beach shaving was done at Siletz Spit in 1973 to provide sand to cover a revetment to enable dunegrass planting. In 1985, limited shaving was allowed to rebuild an eroded dune in front of a low marine terrace at the Sea Ridge development in Lincoln Beach. Each of these examples is characterized by (1) limited removal, (2) one-time excavation as part of a more-permanent stabilization effort and (3) retention of sand in the beach, dune system (except at Kla-ha-nie where sand was placed behind the riprap.)

Earlier stated facts on dune processes indicate the need to avoid excessive alteration of the natural beach slope. As noted, beach slope is a critical factor in dissipating wave energy, thus minimizing shoreline erosion and flood damage. Sand shoved from the beach area should be used to maintain the same slope angle into the foredune foreslope area.

Care must be taken because extensive excavation of sand can steepen the slope of the beach increasing potential wave run-up and beach erosion during storms. As noted earlier, beach slope is a critical factor in dissipating wave energy and minimizing shoreline erosion and flood damage. Also bulldozed sand that is "mounded" into a dune, and then vegetated provides less protection than a naturally-built dune. The mounded dune will only be vegetatively stabilized near its surface. When the top of the dune erodes the core of unstabilized sand is exposed and rapidly erodes. A naturally developed dune will have beachgrass 'roots' extending throughout much of its height. Beachgrass 'roots' (actually dormant parts of the plant) help hold the dune together even as it erodes.

Management Recommendations:

1. Beach bulldozing shall only be allowed as part of an overall dune stabilization project whose principal purpose is to increase protection provided by the foredune consistent with this plan and where evidence is provided that there is a surplus of sand on the beach. Sand moved from the beach shall only be used to repair erosion of a foredune area, to promote growth of a new foredune or to widen narrow and low spots in the foredune, to establish an appropriate slope for riprap on a steeply eroded shoreline, or to cover revetment for the purpose of planting beachgrass.

2. Beach bulldozing shall remove only a thin layer of sand from the beach. The amount of material removed shall not change the grade of the beach (from the low tide line to the toe of the foredune) by more than __%. Depth of excavation shall not exceed 1 foot below the existing surface elevation. Sand shall be moved from the portion of the beach immediately seaward of the site to be filled unless there is a surplus of sand in the beach and dunes protecting adjacent areas.

3. Bulldozing of sand landward of the foredune crest or out of the vicinity of active rip currents shall not be permitted.

4. Dozed areas above the summer high tide line shall, as necessary, be smoothed to conform to adjacent areas that have not been dozed and revegetated.

5. Beach bulldozing shall not be done to excavate sand from the beach system for removal to a back area.

Sand Mining/Removal

While sand has not been mined or removed from the Nedonna-Rockaway area this practice has occurred elsewhere on the Oregon Coast. For example, sand has been cleared from in front of the Seaside Prom on an ongoing basis to maintain an open sand beach there. Mining or removal of sand from the dune-beach-nearshore system is inappropriate because it reduces the amount of material available to absorb ocean wave energy. Further, indiscriminate removal of sand (for mining or mineral extraction) can disrupt the natural system and initiate or accelerate erosion. (Lindberg, Uses, Impacts and Management Considerations in Beaches & Dunes Handbook for the Oregon Coast, 1979, p. 5). Also sand mining at Lincoln Beach may have contributed to the severity of erosion at Siletz Spit in 1972-73 (Komar, 1978).

The importance of sand supply to natural dune processes causes leading experts to recommend that mining of dunes for sand should be banned completely. (Clark, 1977, 332). Studies for the Oregon Coast suggest that sand removal should only be permitted where:

- in-migrating sand is posing a threat to structures, habitat, land or property [or]

- significant accretion is known to occur (however, due to a possible zero net littoral drift and limited sources of new sand supplied to Oregon's beaches, removal of sand even from areas of historic accetion is not recommended.) (Lindberg, Sand Removal, Beaches and Dunes Handbook for the Oregon Coast, 1979, pp. 17-18).

There is no evidence that substantial amounts of new accretion are occurring in the Rockaway-Nedonna Beach area which would justify sand removal. (If substantial accretion did occur, efforts should be made to stabilize it as part of a widened foredune.)

Sand removal from the beach requires permits from the Division of State Lands, the State Parks and Recreation Division (oceanward of the beach zone line) and from the Corps of Engineers. Implementation of Goal 18's foredune grading provisions requires that removal of sand from the beach foredune system be prohibited.

Management Recommendation

Mining or removal of sand from the beach and foredune system should be prohibited.

RESIDENTIAL DEVELOPMENT

Permanent development on foredunes may cause major alterations to the beach-dune system. This is particularly true if development is located on portions of the foredune that are subject to long-term erosion or ocean flooding.

As noted earlier the foredune is a dynamic landform continuously being reshaped by ocean waves, storms, and currents. Development attempts to fix the foredune in place and, in essence, cuts off the foredune as a reservoir of sand to the rest of the beach-dune system. If structures are located too far forward, are unprotected or are inadequately protected, ocean storms will erode the foredune and damage or destroy homes. If seawalls or revetments are installed the natural system is disrupted and beach erosion results.

The most dramatic examples of inappropriate foredune development in Oregon are Bayocean Spit and Siletz Spit.

> "During severe episodes of erosion of Siletz Spit (in 1972-73), the foredunes were cut back some 100 feet around the lengths of ocean-facing lots. Studies of aerial photographs dating as early as 1939 show that such erosion has occurred repeatedly in the past, but

that following the erosion, beach sand is washed and blown into the eroded zone eventually rebuilding the foredunes (Rea, 1975; Rea and Komar, 1975; Komar and Rea, 1976b)." (Komar, 1979, p. 34)

"It would have been preferable if development on Siletz Spit had been prohibited in the approximately 100 foot zone where foredunes are susceptible to rapid wave undercutting and erosion. Then the natural cycle of erosion followed by dune rebuilding could have continued. Instead, the presence of the homes necessitated the placement of huge quantities of riprap." (Komar, 1979, p. 35)

While these two situations were both narrow sandspits rather than open coastline, they still indicate the extent of erosion that can occur in foredunes in a major flood or erosion event. Also the north end of Nedonna experienced similar rates of erosion in 1977-78. For these reasons residential development of all types is generally discouraged in foredune areas. Statewide Planning Goal 18 (Beaches and Dunes) prohibits new residential, commercial and industrial development on foredunes subject to wave overtopping and ocean undercutting (i.e., erosion). However, most of the study area is exempted from this prohibition because it was either developed or committed to development prior to the effective date of Statewide Planning Goal 18 (Beaches and Dunes).

New houses as well as remodeling and other improvements are allowed in developed foredune areas. Nonetheless, the location of these improvements can have an important influence on the stability of the foredune. New or expanded structures or improvements in foredunes can also directly or indirectly damage the foredune or stabilizing vegetation.

"The construction of any development typically requires that the natural setting be modified in preparing the site. When preparing a site on a sand landform the actions involved often destroy the stabilizing vegetative cover exposing the underlying sand to the forces of erosion.

This erosion weakens the structure of the sand landform and decreases its value as a sand reservoir and buffer (Olsen and Grant, p. 31). Examples of specific actions and impacts are:

(1) The lowering of foredune increases the washover potential, salt spray kill-off and wind erosion;

(2) The disruption of dune vegetation can result in destabilization and blow-outs.

(3) The construction on certain foundations in this windblown environment may cause erosion/accretion activities similar to those of jetties by having sand accumulate on the lee side and eroded on the windward side. Certain alignment of structures may also alter wind flows causing simlar erosion/accretion activities in the immediate vicinity." (Lindberg, 1979, pp. 10, 11)

Most construction at Nedonna Beach, particularly recent construction, has not seriously damaged or reduced foredune height. However, there are other places on the Oregon Coast where foredunes have been improperly graded thereby lowering the crest or destroying stabilizing vegetation leading to the erosion problems described above.

Minor improvements or structures which have only minimal or negligible impacts on dune stability and which do not commit the foredune to structural protection are generally appropriate in forward (i.e., oceanward) portions of the foredune. This category includes minor improvements like windbreaks or free standing decks which are neither extensive nor involve much capital investment.

New structures or large or extensive accessory structures, like an addition or a garage, which do disturb a larger area and which involve a substantial investment are appropriate only in back dune areas, away from the area likely to be eroded.

Setback Line

Development in foredune areas should be set back well beyond the point of the maximum probable erosion event. All building should be restricted to the backslope with no encroachment on the crest area. In this way, the beach and foredune can cycle through the natural process of erosion and repair without the necessity of structural stabilization of the shoreline to protect oceanfront homes. (Where the shoreline is retreating because of long-term erosion the setback line should also consider the annual rate of erosion and the life of the structure and replacement structures.) Most residential development in Nedonna Beach and Rockaway Beach appears to be set back far enough to withstand periodic episodes of beach erosion. An examination of aerial photography shows that most residences are located behind the 1939 shoreline location, which is the maximum extent of ocean erosion in most of the study area over the last 50 years. Notwithstanding these facts, it is possible that major beach erosion could occur anywhere in the study area. In fact several parcels in the study area, including the northern portion of Nedonna Beach, were riprapped in response to erosion events in 1977-78.

Most of the study area has suffered some erosion over the last 46 years. However, the foredune has been of sufficient width and erosion events have been modest enough so that existing homes have not been destroyed by erosion. However, this condition may not continue. Based on historic erosion events on this stretch of coast and on other parts of the Oregon Coast it is reasonable to expect that 150 to 200 feet of erosion could occur in any part of the study area. Consequently, a setback of 150 to 200 feet from the front of the foreslope for new residential development would be advisable.

However, most of the study area existing residential development encroaches on the recommended setback. In these areas a widened and heightened foredune should be promoted. This would begin to provide adequate protection from erosion and flooding. Also, the location of existing dwellings relative to the shore should be used as a setback line for new dwellings or improvements. This would require that new dwellings be located in line with existing adjacent buildings. (The City of Rockaway Beach currently has such a requirement based on setbacks of adjacent homes from the beach zone line.)

On-site waste disposal systems would be subject to the same erosion hazards as other structures. Drainfields fertilize dune grass causing denser growth which creates uneven dunes and an extreme fire hazard. Also European beachgrass will create an extensive feeder root system (as much as 50' in diameter) clogging the drainfield, thereby reducing or destroying its effectiveness. Vegetation with less aggressive root systems should be planted in drainfield areas.

Management Recommendations

1. New or expanded residential or commercial structures should be located landward of the line of existing development. If so located interference with dune processes or an earlier need for shoreline protective structures might be avoided.

2. Site preparation, like residential development, is appropriate only behind the line of existing development. Site preparation should be done with care to avoid effects on adjacent foredune crest and backslope areas. Excavated sand not used on site should be used to fill in low spots in the foreslope and crest of the foredune on the site or adjacent lots.

3. Remodeling which does not expand or relocate the structure oceanward is appropriate. Such changes would not have important new effects on the foredune which require additional regulation.

4. Accessory structures are major constructed improvements and, like residences, are only appropriate landward of the existing setback line.

5. Sewage disposal systems should be prohibited in all three parts of the foredune (foreslope, crest, and backslope). On-site waste disposal systems should be installed only in the back area suitable under DEQ, County or City requirements with the condition that no beach grass be planted over them.

Minor Structures

Other structures associated with residential use in dune areas include windbreaks, decks, and small open sided shelters. While such structures are rare in the study area, they may be proposed in the future. Minor structures need to be properly sited and built because any structure in the foredune has the potential to interfere with wind patterns or destroy stabilizing vegetation. The foreslope is particularly sensitive to alterations while the crest is less so.

Management Recommendations:

1. Minor structures built oceanward of existing homes should be limited in size and location so that they do not destroy needed stabilizing vegetation or disrupt wind patterns across the foredune. Except for pile supported boardwalks, no structures should be located on the foreslope.

2. Minor structures such as boardwalks and freestanding decks should be built on pilings and elevated above stabilizing vegetation. Alteration of the foredune or movement of sand should be limited to placing of piles.

VEGETATION MANAGEMENT

Vegetation, particularly European beachgrass, plays a critical role in maintaining the stability of the foredune. The foredune has grown to its present height, width, and shape largely because of the ability of European beachgrass to trap and hold windblown sand. If the beachgrass is damaged or destroyed, winds will literally blow the dune away. Inland areas will be covered with sand, and flood protection provided by the foredune will be compromised. Because of the importance of vegetation and its sensitivity to damage, all man-caused changes to dune vegetation should be controlled. These includes planting, grazing, fertilizing, mowing, and application of herbicides or other chemicals.

Management of vegetation includes both regulating and prohibiting actions which would harm dunegrass and taking steps to encourage a well-vegetated foredune. As noted elsewhere, the foredune in the study area has been extensively altered and in many areas is too low and narrow to provide effective protection from serious flooding events. Planting bare spots and fertilizing existing European beach grass can help these sections of the foredune heal.

Despite its importance and effectiveness in stabilizing dunes, or perhaps because of it, many oceanfront property owners have removed, destroyed or altered stands of beachgrass. Most have cleared the grass to prevent further sand accretion, while some simply consider dune grass a nuisance or prefer open sand. Such alterations are generally not harmful in back areas where beachgrass is often not needed for stabilization and may in fact be a fire hazard. Unfortunately, many alterations have occurred in the foreslope and crest where almost any alteration interferes with the grasses stabilizing ability. The following sections describe how particular activities can impact dune vegetation and how they ought to be regulated.

Alterations to vegetation are typically not regulated by local governments or state or federal agencies. Such regulation is limited because it is considered an unnecessary infringement on the right to use property. It is also quite difficult and expensive for government agencies to administer such controls. However, vegetation plays so critical a role to the stability of dunes and safety of oceanfront development that additional regulation of changes to vegetation is necessary.

Direct regulation of vegetative alteration (i.e. by permit) is considered unworkable and unnecessary. Instead, an indirect system is recommended. This would involve an educational program to inform properly owners of the importance of vegetation and proper management techniques. The city or county would periodically monitor the area to make sure vegetation is being managed consistent with the recommendations noted above. Where a recommendation has been violated the county would inform the property owner and seek restoration. If the problem is not resolved the county would cite the violator and conduct needed restoration activities.

Planting European Beachgrass

Planting of European beachgrass on the crest and foreslope will be critical to strengthening the foredune and repairing occasional damage. As noted above, this grass has the ability to trap and stabilize large amounts of wind blown sand. Established European beachgrass can survive and stabilize sand accretion to the height of the grass (18"-24") per year (and more if fertilized). European beachgrass is also the most effective means of stabilizing recently filled or graded areas.

If improperly planted or damaged, beach grass will fail or create only patchy coverage. Patchy survival will result in hummocks and discontinuous rather than uniform dune growth. This results in less protection against erosion and flooding than would be provided by a uniform dune. Replanting to achieve uniform dune growth is advisable in such situations.

Beach grass needs a continuing supply of fresh sand for fertilization. For this reason it is inappropriate in back dune areas, where very little new sand accumulates. The exception is the use of beach grass as an initial stabilizer in open sand areas. Beach grass plantings in open sand back areas should be followed quickly by introduction of climax species to replace the beach grass. In addition, old stands of beach grass are flammable and can be a fire hazard to nearby homes. Other species of stabilizing vegetation are more appropriate in back dune areas. For example, purple beach pea is an effective secondary stabilizer and is extremely fire-resistant.

Management Recommendations:

1. Open sand areas in foredunes should be planted with European beachgrass according to the specifications in the Grading Plan.

2. Any graded or filled area which is unlikely to re-establish dune grass because of the absence of vegetation or the depth of grading or fill (i.e., where grading removes more than 3' or where fill over a vegetated area exceeds 3 feet) should be replanted according to the specifications in the Grading Plan. (This includes areas of the foreslope, the forward portion of the crest; the back portion of crest and all open sand areas larger that 20 square feet.)

3. Fire-resistant species are the preferred stabilizing vegetation within 25' of existing dwellings or structures. Where revegetation is required within 25' of structures the initial or secondary plantings, as appropriate, shall be to fire resistant vegetation, such as purple beach pea. Rock blankets can also be an effective firebreak around homes.

Mowing of Vegetation

Several homeowners have mowed beachgrass, usually to provide a better view of the beach or ocean. The effects of mowing on the dune depend on the time of year and the part of the dune that is mowed. European beachgrass itself will survive and regrow after being cut. In fact, like other grasses, European beachgrass will respond by putting out more blades of grass per plant. Once cut, beachgrass loses most of its ability to trap windblown sand. For this reason, mowing should never occur on the foreslope since vegetation there is almost always receiving some windblown sand.

Mowing of beach grass on the foreslope of the foredune allows free passage of windblown sand to the crest and backslope areas. This tends to build the height of the crest area and buries things located on the backslope. Mowing beach grass on the crest area of the foredune allows free passage of windblown sand from the beach if foreslope vegetation is not sufficient to trap the sand. The result is buried structures and destruction of climax vegetation. Mowing beach grass in backslope or back areas has no impact on the stability of the foredune system and will reduce the fire hazard caused by old, dry stands of starved beach grass.

Management Recommendations:

1. Mowing of crest and backslopes should only be done between March and October and then only if the foreslope area is sufficiently vegetated to capture accreting sand.

2. All mowed areas shall be fertilized with 21-0-0 ammonium sulfate at a ratio of 100 pounds per acre.

Application of Herbicides

Herbicides can destroy stabilizing dune vegetation. The first effect of herbicides is a stand of dead, dry vegetation which is a severe fire hazard. Eventually the vegetation decays and is removed or buried and an open sand areas results. Sand movement is reactivated reducing the height or width of the foredune and resulting in reduced protection from flooding and erosion. Use of herbicides can be appropriate in back dune areas as part of a program to establish secondary stabilizing vegetation, a yard, or a firebreak. Use of herbicides for these and similar purposes needs to be carefully limited to assure that damage to the foreslope and crest does not occur and that the back dune area is not reopened to wind erosion.

Management Recommendations:

1. Use of herbicides to control or eliminate vegetation in back dune areas (i.e., behind the backslope) should only occur where the foredune in front of the area is functioning to block wind erosion and sand accretion. Spraying should not occur when the wind is blowing.

2. Herbicides should be applied with care so that vegetation on back dune, crest or foreslope is not sprayed or affected. Vegetation in crest and foreslope areas damaged or destroyed by application of herbicides should be promptly restored with stabilizing vegetation. All spraying of herbicides should be done following directives from the County Extension agent or SCS technician.

3. Back dune areas should be promptly replanted or stabilized to avoid wind erosion of open sand areas.

Nonstabilizing Vegetation

Homeowners have and will continue to landscape their property to improve its aesthetic and economic value. Planting and propogation of nonstabilizing vegetation in back dune areas (i.e., landward of the backslope) is appropriate since such areas are not subject to continued sand accretion. Planting of nonstabilizing vegetation in foreslope, crest and backslope areas is generally inappropriate. Such plantings usually involve destruction of existing stabilizing vegetation and the new vegetation is unable to withstand the accretion of sand. Nonstabilizing vegetation eventually fails, reactivating the area to wind movement and causing sand build-up in inland areas.

Management Recommendation

Non-stabilizing vegetation, including ornamental landscaping lawns, and gardens, should be located in back areas only.

Firebreaks

Beachgrass and other herbaceous vegetation dry out during summer and fall months and may create a fire hazard for some oceanfront dwellings because fire can spread rapidly through dune grass. (Beachgrass will, however, recover from fire.) Unvegetated firebreaks (i.e., open sand areas) around houses are counterproductive in most dune areas because they can result in blowouts around the foundation of the house. Certain types of stabilizing vegetation, most notably purple beach pea, are fire-resistant and can form an effective firebreak around oceanfront homes and reduce the potential for blowouts in backslope and back dune areas. Fire-resistant vegetation introduced into wind stable back dune areas will generally succeed even healthy stands of beach grass through natural competition.

Unvegetated firebreaks such as rock blankets are an appropriate means of providing protection to oceanfront homes.

Management Recommendations:

1. Fire-resistant vegetation should only be planted when the foreslope and crest are adequately stabilized to prevent significant accumulation of windblown sand.

2. Fire-resistant vegetation should not be planted in the foreslope. Fire-resistant vegetation planted in the crest or back slope must be able to withstand some sand accumulation; purple beach pea is recommended.

3. Fire-resistant vegetation should be planted in existing stands of beach grass. Where planting of fire-resistant vegetation involves removal of existing stabilizing vegetation (i.e., beach grass) it shall be done in areas of not greater than 500 square feet per year in order to assure that new vegetation is properly established and that open sand areas are not created.

4. Rock blankets may be used in backslope areas in place of stabilizing vegetation where the foreslope and crest are adequately stabilized to prevent significant accumulations of windblown sand.

BEACH ACCESS

Beach access includes both pedestrian and vehicular access from public and private lands between back dune areas and the beach. Improperly located or over-used accesses can destabilize the foredune by trampling dunegrass and creating a low spot subject to wind scour. Some controls are needed to assure that accesses are properly designed and maintained.

Public Access

Public pedestrian access is necessary to provide for public use and enjoyment of public beach areas. Inadequate public access discourages public use of the beach and encourages trespassing across private property. Improperly sited or over-used public access points can destabilize the foredune by destroying vegetation leading to blowouts. Dune vegetation is so sensitive to disturbance that even limited foot traffic across the dune can lead to serious damage to the foredune. If vegetation, particularly european beachgrass, is repeatedly trampled, it dies and its sand trapping function ceases. If the pathway is oriented into the prevailing winds, this can result in a blowout of the foredune. Blowouts cause a loss of sand from the beach and dune to inland areas and can provide an avenue for intrusion of ocean floodwaters to low lying areas behind the foredune. Also, pathways once created tend to attract use because of the inconvenience of walking through stands of sharp-tipped dune grass.

Most public accesses in the study area have not harmed the foredune because of their size, orientation and limited use. Public accesses are typically narrow pathways (up to three feet wide) running east-west, which receive only low to moderate pedestrian use. This combination of factors, particularly the orientation of accessways away from erosive winds (northwest and southwest winds), has prevented blowouts. At the jetty parking lot in Nedonna Beach indiscriminate vehicular access across the foredune has either destroyed stabilizing vegetation or prevented it from being established.

Some public access points, particularly street ends are inadequately used because they are not signed. This often leads to trespass across nearby private property.

Management Recommendations:

1. Pathways from the back area to the beach should be located east-west.

2. Pathways shall not exceed four feet in width in order to maintain as much vegetation as possible and to discourage vehicular use of pedestrian paths.

3. Where blowouts occur at public access points they should be promptly stabilized with beachgrass and, as appropriate, fenced and signed to direct pedestrians to acceptable access points.

4. Signs should be placed on the foreslope and at landward entrance points to public accesses to encourage use of established pathways and discourage trespass across nearby private property.

Vehicle Access

Vehicles, because of their size and weight can severely damage dune vegetation with even very limited traffic. Use of the beach by private vehicles throughout the study area is prohibited by the Oregon Department of Transportation under the Beach Law. Vehicular access to the beach in emergencies is allowed. Situations where vehicles may be appropriate on the beach include Coast Guard Search and Rescue at the jetties, oil spill clean-up, haul out of grounded boats, clean up of debris from barge or ship sinking or access for construction equipment for shoreline stabilization or other permitted beach/dune alterations.

The present vehicle access at the Jetty Parking lot at Nedonna Beach has destabilized the foredune there. The result is a breach of the foredune creating an opening for intrusion of windblown sand and ocean storm waves to the parking lot and inland areas. The County Road Department has periodically removed accumulated sand from the parking lot to keep it clear.

Management Recommendations

1. Vehicular access points should be located only in dune areas where it is possible to orient the access so that it does not cause a foredune blowout.

2. Vehicular access shall be designed, constructed and maintained to assure the foredune is not reduced in height and that stabilizing vegetation on either side of the access route is retained. Access routes shall be as narrow as possible to permit use by emergency vehicles (i.e., 10-12 feet wide). Fencing or signing may be necessary to assure routes are used and adjacent vegetation is maintained.

3. ODOT's prohibition on vehicular use by the general public is appropriate and should be continued because it would be difficult to regulate or prevent traffic from damaging the foredune.

Private Access

Private pedestrian access routes, like other access routes across the foredune, can result in trampling of stabilizing vegetation to the point a blow-out is created. While private pedestrian routes have been a problem on high traffic beaches, Rockaway Beach and Nedonna Beach appear to receive light enough use that pedestrian access has not severely damaged vegetation or created blowouts. Most private accesses are located east-west, away from the direction of potentially erosive winds. If this pattern of use changes, then some control over private accesses may be appropriate. Some residents have expressed concern that the foredune is a barrier to beach access by elderly and physically handicapped persons. Boardwalks or hard surface pathways are the most appropriate solution where this is a problem. The boardwalks should be built on pilings and the walkway elevated above stabilizing vegetation.

Management Recommendation

Private pathways should be encouraged to follow the recommendations set for public pathways, but regulation is unneccessary at this time.

OTHER ALTERATIONS

There are a number of other of human activities which can adversely affect dune stability but which fall outside of the categories listed above. Most are usually not regulated by zoning ordinances or are subject to only minimal requirements. However, because the foredune is sensitive to virtually any alteration, some additional regulation of these activities is appropriate in the foredune. The specific alterations discussed here include: windbreaks, open-sided shelters, fences, operation of motor vehicles and fires.

Motor Vehicle Operation

Unregulated operation of motor vehicles (particularly off-road vehicles) in vegetated dunes damages and can destroy stabilizing vegetation. At a minimum, such activity impedes growth of the foredune. In contrast, the beach can withstand substantial vehicle use. It is extremely difficult to ensure that beach traffic does not spill over to dune areas. Despite some reports of use by three-wheelers, single seat all-terrain vehicles, off-road vehicles do not appear to be a major problem in the area. This is probably due in large part to the Department of Transportation's current prohibition on operation of motor vehicles on the beach in this area (except for emergency vehicles).

Access across the foredune by vehicles for emergency operations, such as search and rescue, fishing boat removal or foredune grading, should cause little impact on dune stability because such activities are infrequent, and because they occur in selected locations where damage can be minimized or mitigated.

Management Recommendation

ODOT should continue its prohibition on operation of motor vehicles on beaches in the Rockaway/Nedonna Beach areas. City, County and State agencies should monitor and vigorously enforce this prohibition.

Fires

Open fires in vegetated dune areas are a major fire hazard to adjacent homes and can threaten dune stability because of high winds and the flammability of most stabilizing vegetation, particularly beach grass. Even fires close to vegetated dunes are a hazard because of the potential for wind-borne coals to start grass fires.

Fires on the beach which are properly set back from dune vegetation can be conducted with little hazard to adjacent development. Camp stoves and charcoal barbeques are preferable since they are more easily controlled and less susceptible to winds.

Management Recommendations

1. Open fires in or near vegetated dune areas should be prohibited. Open fires are appropriate on the beach or in back yards if they are set away from flammable dune vegetation.

2. Oceanfront property owners should be encouraged to plant fire-resistant vegetation near their homes to serve as a fire-break. If fires occur, burnt areas should be promptly restabilized by fertilizing with 200 pounds of 21-0-0 ammonium sulfate during rain or with irrigation.

CREEK OUTLETS/EMBAYMENTS

Three activities, riprap, stream clearing and log removal, have been conducted in the past in stream embayment areas to protect existing uses there. These are discussed below. Other uses and alterations are generally inappropriate in stream embayment areas because of the potential for adverse effects on other areas and the inadequate information on the dynamics of these areas and the effects of physical changes to them.

There has apparently been some discussion in the past by the community of closing off or consolidation of the stream outlets as a long-term solution of flooding and erosion caused by embayment areas. This would involve linking two or more of the lakes together, and blocking off one or move outlets and slightly enlarging another. A more dramatic proposal would link all of the lakes between Nehalem Bay and Tillamook Bay together and establish a combined outlet directly to one or both bays. All of these proposals would require substantial geologic and engineering investigation beyond the scope of this study. In addition, the cost of carrying out such a scheme efforts is likely to be substantial; probably greatly exceeding the benefits of reduced flooding or erosion.

Most alterations of the stream embayment areas are regulated by the Division of State Lands. The Removal-Fill Law, administered by DSL, requires a permit for placement or movement of more than 50 cubic yards of material on the beds or banks of a stream or the beach. This covers virtually the entire embayment area and shoreline. The Beach Zone line is generally located oceanward of the embayment shorelines so Parks and DSL's jurisdiction is not coincident in these areas.

Log Clearing

Cutting of and removal of driftwood is an important source of fuel for some residents in the area and has historically been allowed on a noncommercial basis. The Oregon State Parks Division, regulates this activity.

Large accumulations of driftwood (i.e., those wide enough to cover the mouth of a stream outlet) in stream outlets can effectively dam the creek, causing a rise in inland lake levels and flooding of low-lying homes and properties around the lakes. These accumulations are usually the result of ocean storms:

> "...large storms and high tides deposit debris and sand that block the stream outlets of Crescent Lake, Rock Creek and Clear Lake. Heavy rainfall and the resulting run-off then cause flooding adjacent to the lakes and Rock Creek in the vicinity of B Street." (Flood Insurance Administration, p. 4).

When these incidents have occurred in the past, stream outlets have been cleared or partially cleared of driftwood and debris to reestablish previous lake levels.

Large accumulations of driftwood at the mouth of stream outlets can also be an effective barrier to ocean storm wave penetration. If driftwood accumulations are interlocked, usually a result of natural accretion, they can be an effective barrier to ocean storm waves. Improper removal of logs for firewood or as part of a poorly conceived effort to relieve stream blockage can breakdown the interlocking and thus, destroy the ability of log accumulations to prevent ocean wave intrusion.

Small accumulations of driftwood or large poorly interlocked accumulations can actually increase flood damage because as larger logs are floated they become battering rams or missiles powered by ocean storm waves. In the past such logs have caused serious erosion or damage to oceanfront homes.

Management Recommendation:

Removal of log accumulations should be accomplished in a manner which minimizes increased ocean flooding hazards. If the amount of log removal that is required would eliminate the protective interlocking effect of a driftwood accumulation, then most or all of the driftwood should be removed.

Stream Clearing

Accumulations of material in stream mouths, outlets and embayments can effectively dam streams causing them to change their course across the beach or causing flooding in upstream lakes. Lake flooding can and has damaged lakefront homes and properties. Diversion of stream flow across the beach can cause erosion of embayments, threatening oceanfront homes with erosion and increasing the extent of ocean flooding.

Clearing streams of excessive amounts of debris to maintain streams in their present course has been an effective means of mitigating, potential erosion and lake flooding. Removal of more than 50 cubic yards of material requiring a permit from the Division of State Lands.

Management Recommendations:

1. Stream clearing should only be permitted where it is clearly needed to prevent imminent or existing flooding of lakefront areas or to avoid a major natural relocation of a stream channel which would cause erosion of the embayment shoreline.

2. Stream clearing to avoid a change in stream channel location should only be permitted if it is clear that failure to maintain the stream in its present location would create a greater erosion hazard to existing development than relocating the stream outlet.

3. Where stream clearing is permitted the amount of material moved or removed should be the minimum necessary to avoid flooding or reestablish the stream in its existing location.

4. Sand cleared from stream channels should be either placed in eroding portions of the embayment, on nearby foredunes or smoothed evenly across a portion of the embayment to reestablish or enhance the natural beach profile. Sand shall not be removed from the beach/foredune system.

Embayment Stabilization

Stream outlet channels and embayment areas are dynamic features subject to accretion, erosion and ocean flooding. While these features generally appear to be in equilibrium throughout the study area, the extent of their dynamics and the effect of alterations on patterns of erosion and flooding is not predictable.

Occasional episodes of erosion at stream outlets or at the shoreline edge of stream embayments has and can threaten existing oceanfront development. Riprap or bulkheads constructed in response to this erosion appears to have been effective in stopping further erosion generally with minor impacts on adjoining properties. Fill of embayment areas appears to have caused erosion of nearby areas due to reflected wave energy.

Riprap has generally had less adverse effect on erosion of adjacent properties than seawalls or bulkheads because of its ability to absorb wave energy or divert it upward rather than reflecting it directly back on the beach. Bulkheads have been necessary for erosion control in some stream outlets because the shoreline between the stream and adjacent development is too narrow to allow proper sloping to place riprap.

Management Recommendations

1. Structural shoreline stabilization in embayment areas should only be allowed where erosion clearly or imminently threatens existing structures or developed areas.

2. Structural shoreline stabilization of embayment shoreline should only be done by riprap which meets minimum design specifications recommended in Appendix 6. Filling or riprapping of embayment areas should not be located seaward of the embayment shoreline because it would probably interfere with natural erosion and accretion patterns in the embayment area and would likely cause increased erosion in other parts of the embayment.

3. Stabilization of creek outlets shall be by riprap unless the location of existing structures or improvements adjacent to the outlet make it impractical to construct riprap to the minimum design specifications recommended in this plan. If riprap is impracticable, sheet or timber pile bulkheads may be permitted.

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Appendix A: Definitions

For the purposes of this study the terms listed below have the following meanings:

Shoreline Stabilization

A constructed improvement or alterations attempting to fix the shoreline at a particular location (i.e, to permanently prevent further landward movement of the ocean or beach). Stabilization is usually done to protect existing homes from on-going or imminent ocean wave erosion.

Beach/Dune Alterations

Any activity which involves the placement, movement or removal of sand on the beach or dune including the placement of structures which affects the pattern of sand accretion. This includes sand removal, sand placement, dune grading, foredune breaching, beach bulldozing, placement of sand fences, beach nourishment and vegetative dune stabilization.

Sand Removal--the excavation of sand in a beach or dune area for any purpose, usually done as site preparation, dune breaching, dune grading or beach bulldozing.

Sand Placement--putting sand removed from one area into another area. Placement is usually limited to movement within the beach and dune system but may include movement of sand into the system from offshore, estuarine or upland sources.

Foredune Breaching

Creation or enlargement of a gap in a foredune which has the effect of allowing floodwaters or major amounts of sand to be moved by wind to or from the beach. Breaching includes any dune alteration which reduces the height of a foredune to the extent that 100 year velocity flood waters could penetrate landward of velocity flood zones.

Beach Bulldozing

The grading or movement of a thin layer or layers (6 to 12") of sand from near the low water line landward toward or to the seaward edge of the foredune. Bulldozing is usually done for the purpose of repairing an eroded foredune or to widen or raise the foredune area.

Dune Grading

Mechanical movement and placement of sand usually by a bulldozer which changes the shape or height of a dune.

Residential Development

Any alterations or improvement necessary for or associated with residential use, including home building and expansion, construction of accessory buildings, fences and other minor structures like windbreaks, excavation for site preparation, and placement of septic tanks or similar waste disposal systems.

Structure: A residence, commercial or industrial building or any other built, attached or improvement, including decks and garages.

Expanded structure--an enlargement of an existing structure by enclosure or additional floorspace oceanward of the existing building.

Site Preparation: Any alteration made to ready a building site for construction of a structure including excavating, leveling, filling of sand or removal of vegetation.

Remodeled Structure: Any modification to a structure which requires a building permit but does not increase the lot coverage of the structure, or change the location of the structure.

Accessory Structure: A building or other constructed improvement separate from but used in conjunction with a residential or commercial structure such as a separate garage, a gazebo or a storage building.

Wastewater Disposal System: The excavation and placement of a tank and effluent lines or similar facilities for the treatment and dispersal of household, commercial or industrial wastewater.

Vegetation Management

Any of a variety of man-caused changes to dune vegetation, including destruction, alteration or enhancement of vegetation, planting of vegetation, fertilizing, mowing, and application of herbicides or other chemicals.

Planting Beach Grass: Planting of beach grass for the purpose of stabilizing a dune or establishing vegetative cover.

Mowing of Vegetation: Cutting vegetation by hand or machine including use of a sickle, lawn mower, weedeater or other means.

Application of Herbicides: Spraying or any other means of placing herbicides or other chemicals which are intended to or are capable of killing stabilizing vegetation.

Nonstabilizing Vegetation: The planting or propogation of vegetation that is unable to withstand accretion of sand typically occurring in foredune areas.

Vegetation Management (continued)

Vegetated Firebreaks An area covered by fire-resistant vegetation between a structure and flammable vegetation established for the purpose of preventing the spread of beach or dune grass fires to nearby structures.

Beach Access

Access includes both pedestrian and vehicular access from public and private lands between back dune areas and the beach.

Public Access: A pathway or boardwalk from public property, a public road or a public easement to the beach which crosses public property or travels along a public road, right-of-way or easement. Public accesses do not include accesses across private property unless there is a public right to access, such as an easement.

Vehicular Access: Access points or routes from public property, including a road or parking lot, to the beach intended or designed to allow access by vehicles to the beach.

Private Access: A pedestrian access route from an oceanfront residence or commercial establishment to the beach which is intended primarily for use by residents and guests at that location.

Motor Vehicle Operation: Driving, riding other otherwise operating a car, off-road vehicle or motorized vehicle. This does not include use of vehicles necessary for the conduct of other permitted activities.

Fires: The starting, tending or maintaining of an open fire using driftwood, firewood or any other material, for any purpose including a cook fire, a bonfire or trash burning. Not included in this category is the use of small, self-contained campstoves or charcoal barbecues.

Creek Outlets/Stream Embayments

Stream Outlet -- That portion of the stream or creek which is bordered and confined by the shoreline above the beach. Stream outlets extend shoreward to Highway 101 and oceanward to the point where the stream meets the open, relatively flat beach.

Stream Channel -- The portion of a stream which runs as open water on the beach from the stream outlet to the Pacific Ocean. The channel location may vary daily, seasonally and annually.

Embayment Area -- The entire stretch of beach and shoreline subject to the influence of a stream crossing the beach. This includes the stream outlet, the stream channel and the beach to the embayment shoreline. The extent of each embayment area along the shoreline is defined by the limit of landward recession or erosion in the shoreline associated with the stream channel. The embayment area ends where this influence ends and a relatively continuous foredune, parallel to the ocean shore begins. The emayments area of influence may vary seasonally.

Creek Outlets/Stream Embayments (continued)

Embayment Shoreline -- The landward limit of the beach associated with a stream embayment. This shoreline is usually defined by a current erosion scarp or a foredune in a state of natural repair with little or no vegetation on the foreslope.

Log Clearing

The removal, excavation, movement or sawing of driftwood logs which has accumulated on the beach or in stream outlets or embayments as a result of ocean, storms, or waves, or current.

Stream Clearing

The movement or removal of accumulated logs, sand, stone or other obstructions from the bed or banks of a creek outlet in order to allow freer passage of the stream flow.

Riprap: A means of structural shoreline stabilization consisting of the placement of large, very hard rocks over smaller rocks and usually a cloth filter blanket to provide protection from erosion.

Bulkhead: A vertical wall usually constructed of steel or treated wood-beams to hold a shoreline in place and provide protection from ocean or stream water erosion.

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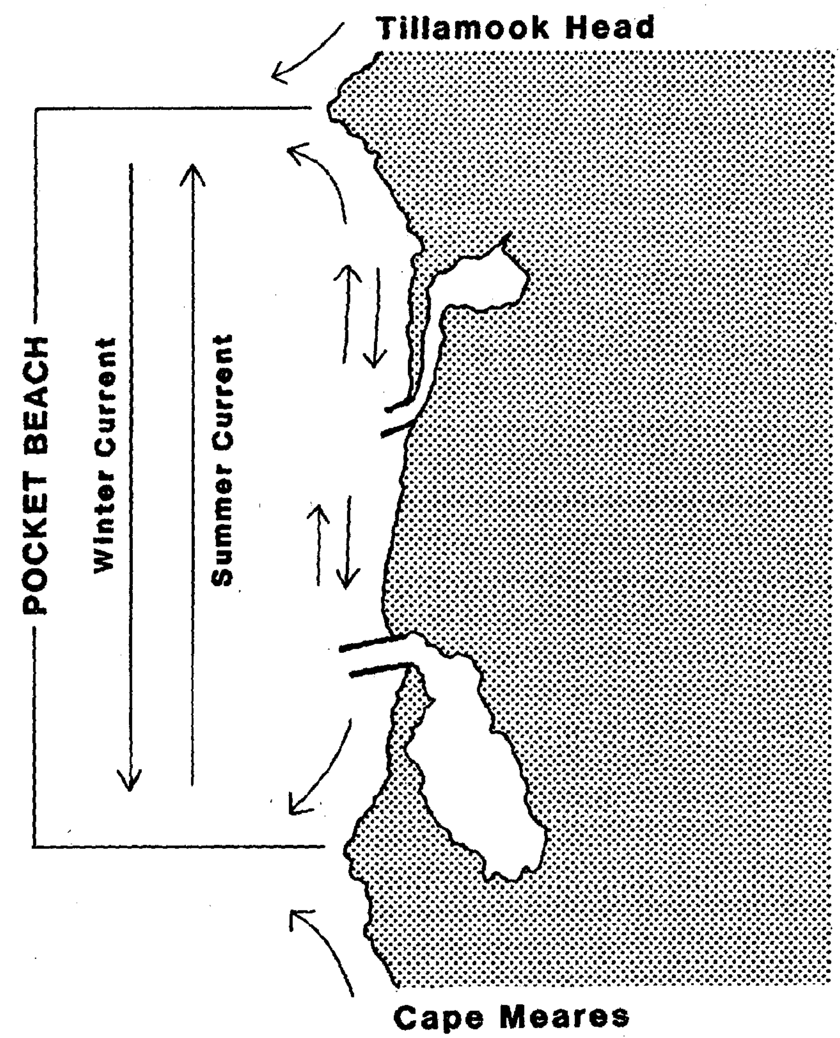
ILLUSTRATIONS

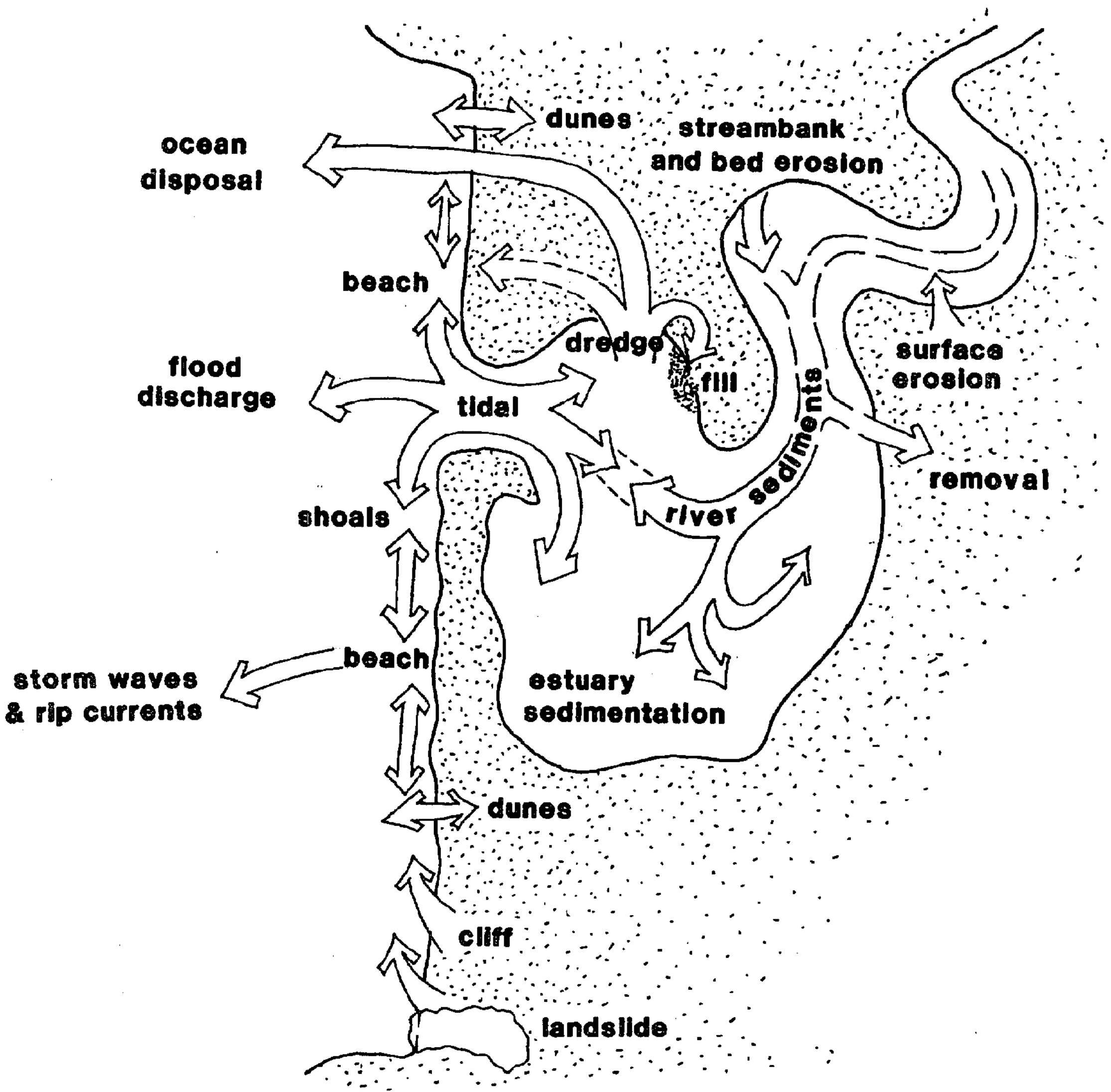
LIST OF ILLUSTRATIONS

POCKET BEACH

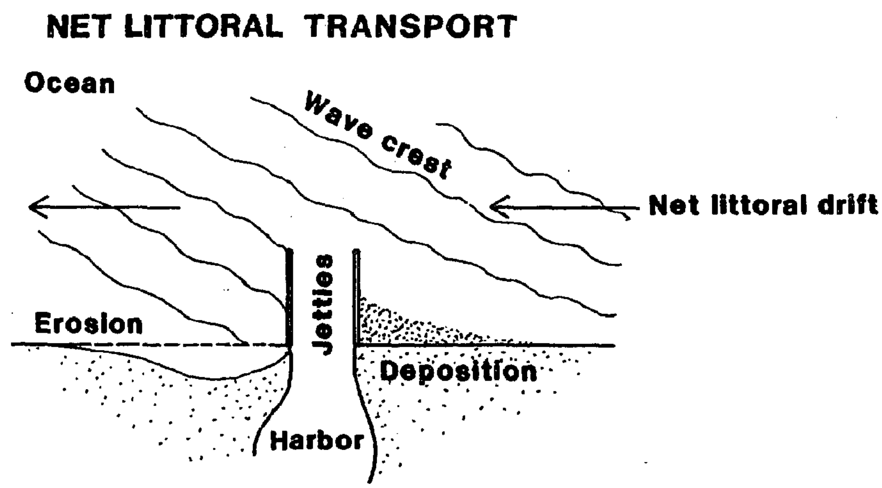


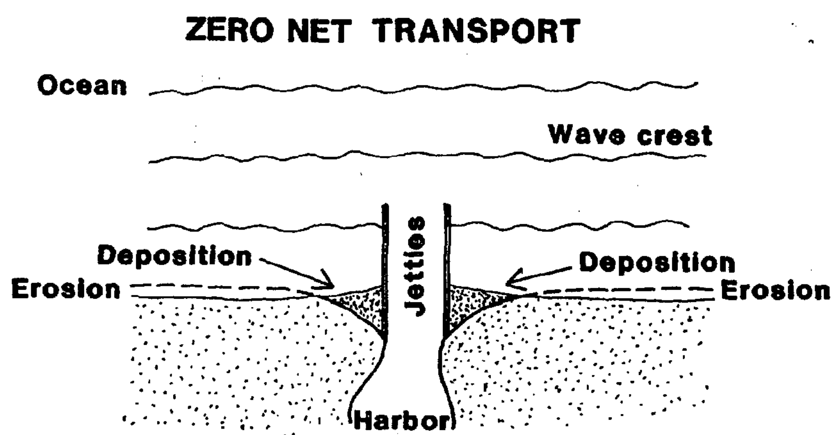
I-2

COASTAL SEDIMENT TRANSPORT



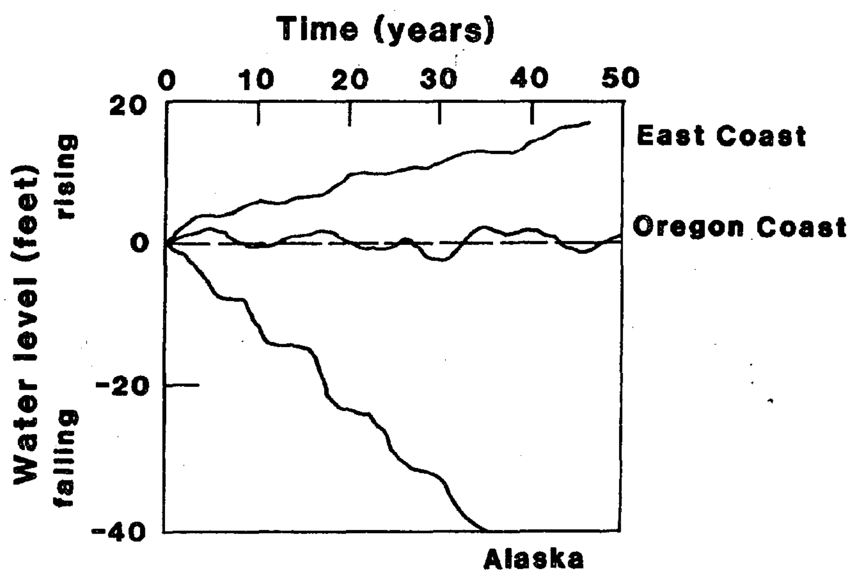
NET VERSUS ZERO LITTORAL TRANSPORT NEAR JETTIES



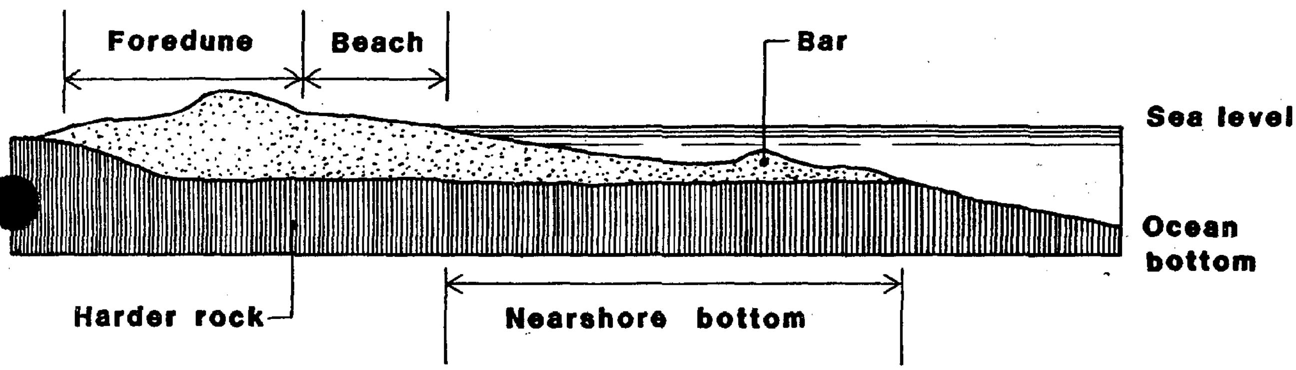


I-4

CHANGES IN SEA LEVEL

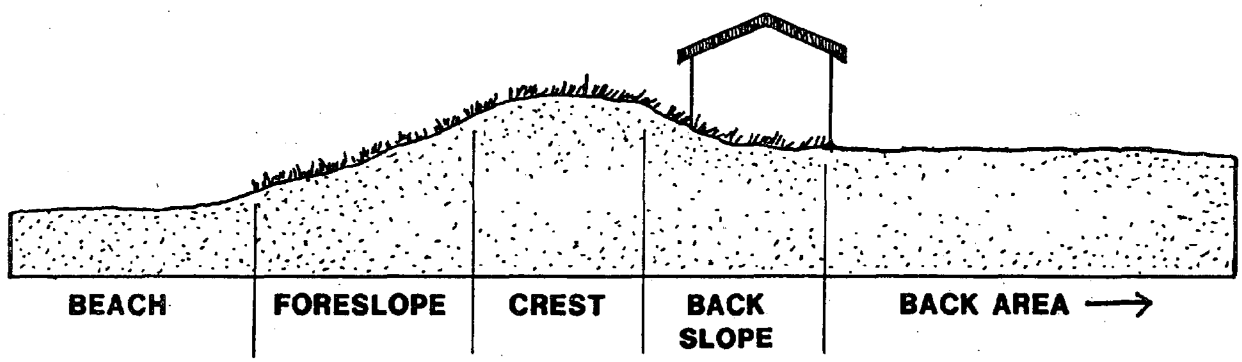


SAND SYSTEM CROSS-SECTION

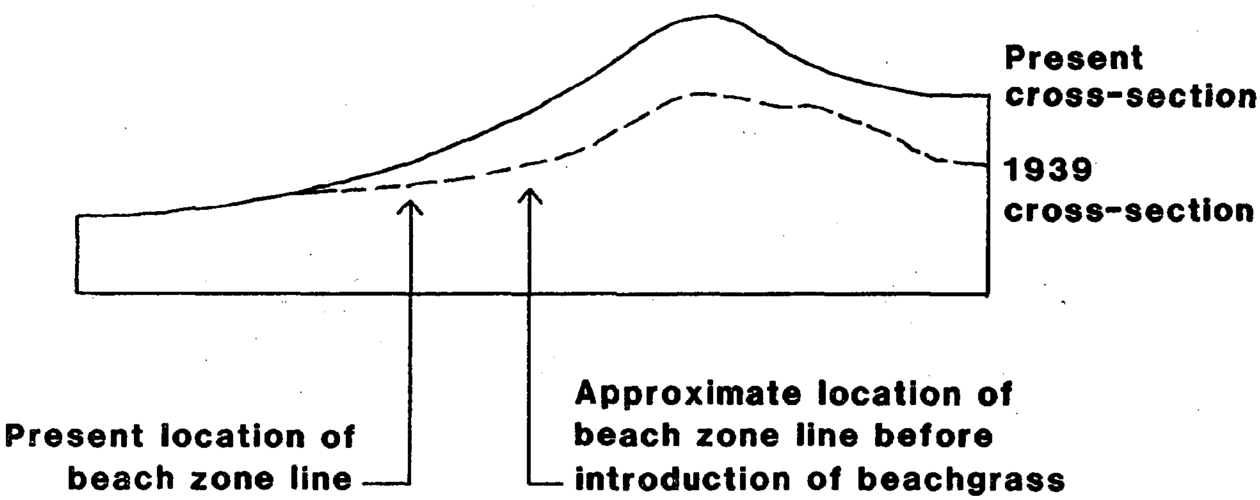


I-6

TYPICAL FOREDUNE CROSS-SECTION

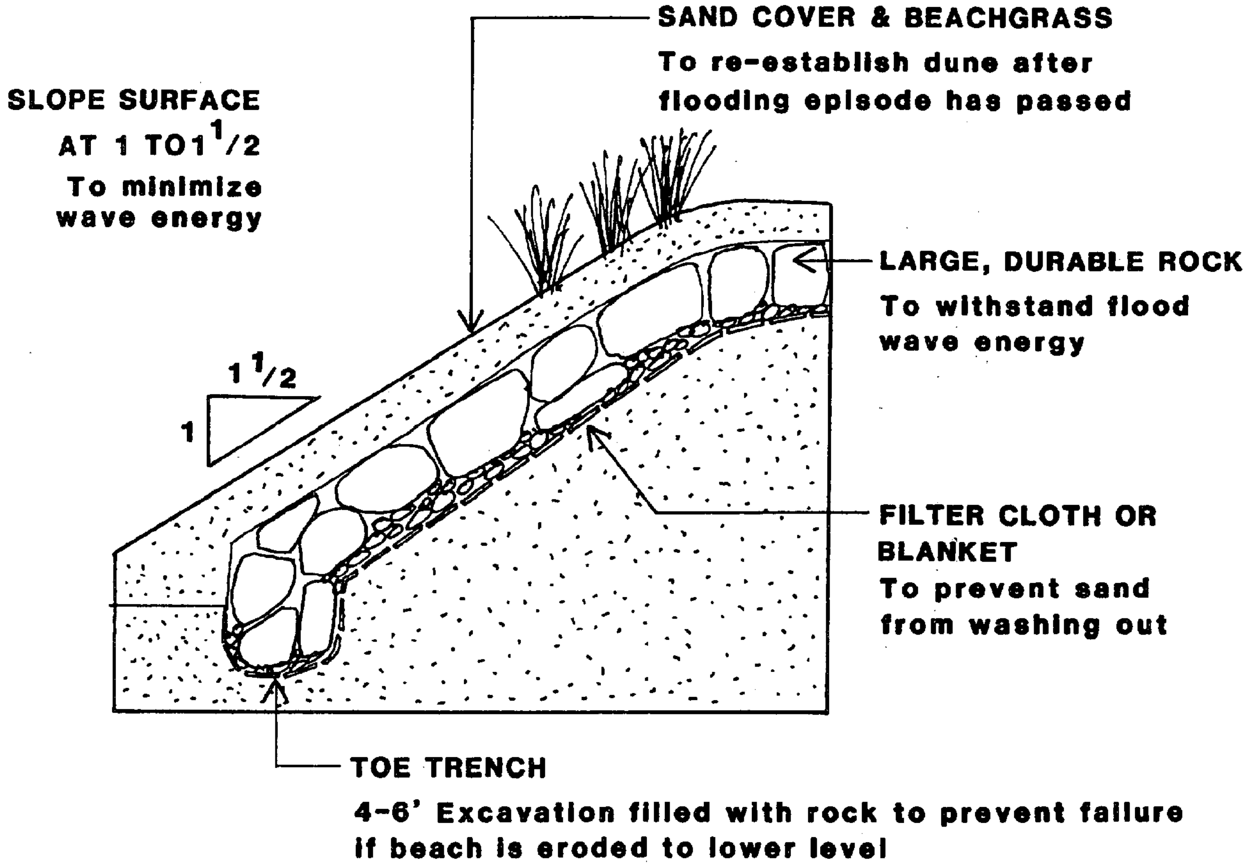


FOREDUNE CROSS-SECTION: BEFORE & AFTER EUROPEAN BEACHGRASS



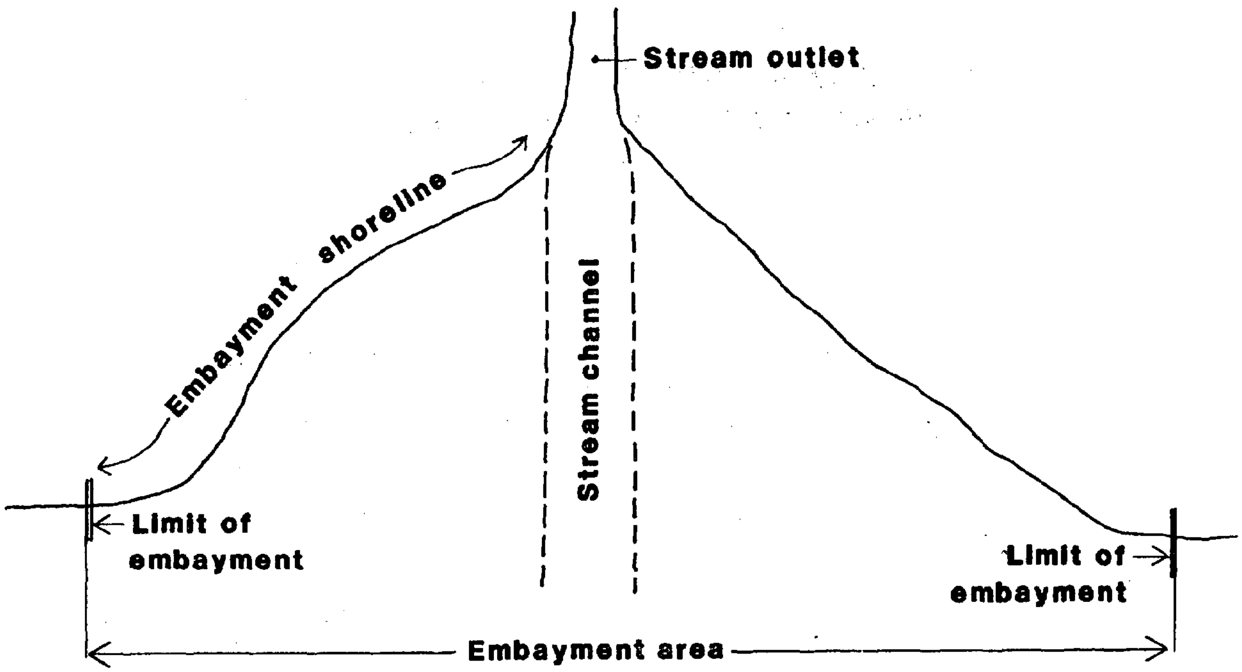
I-8

RIP-RAP DESIGN & PLACEMENT



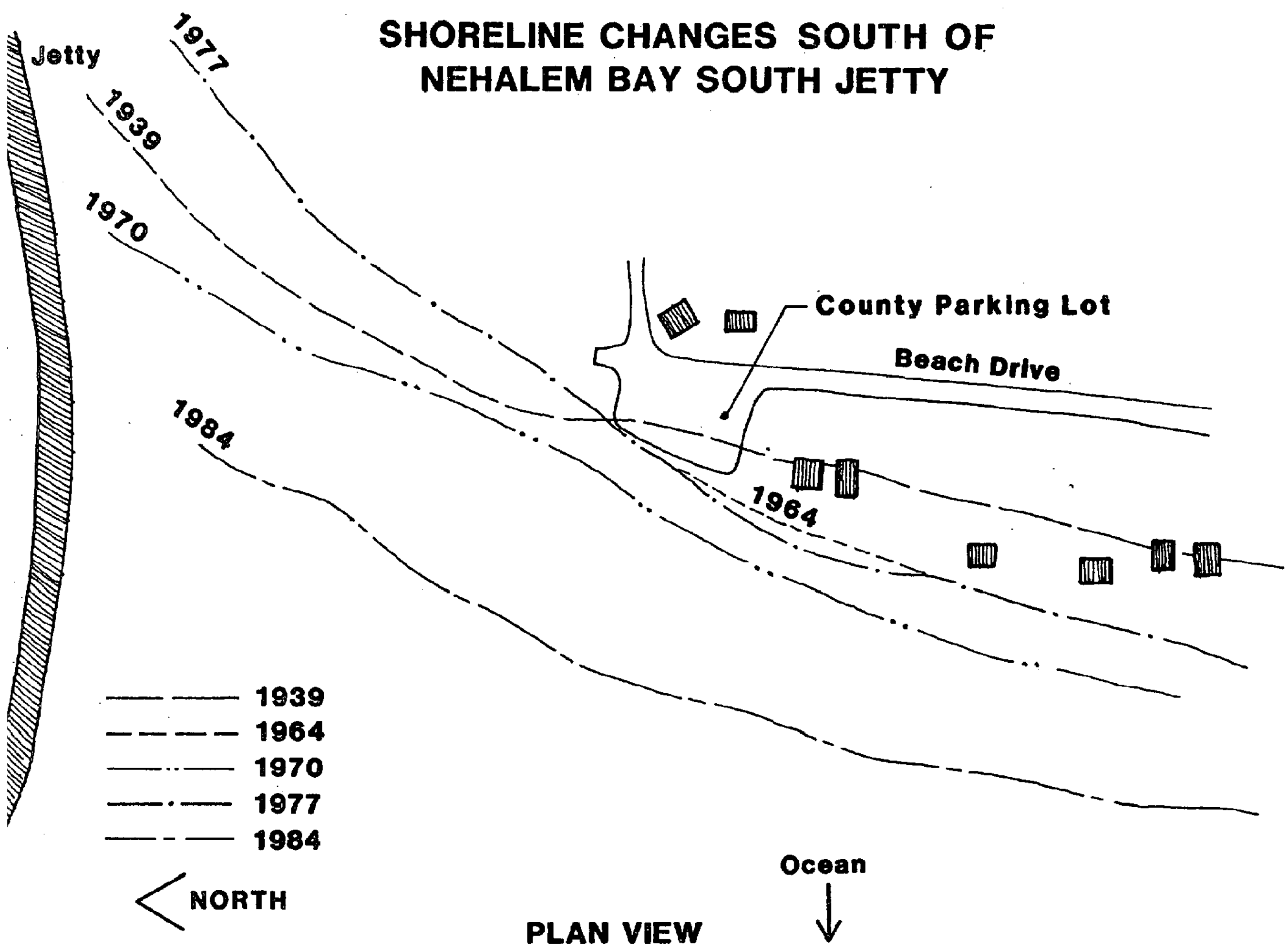
CROSS-SECTION VIEW

CREEK OUTLETS/EMBAYMENTS



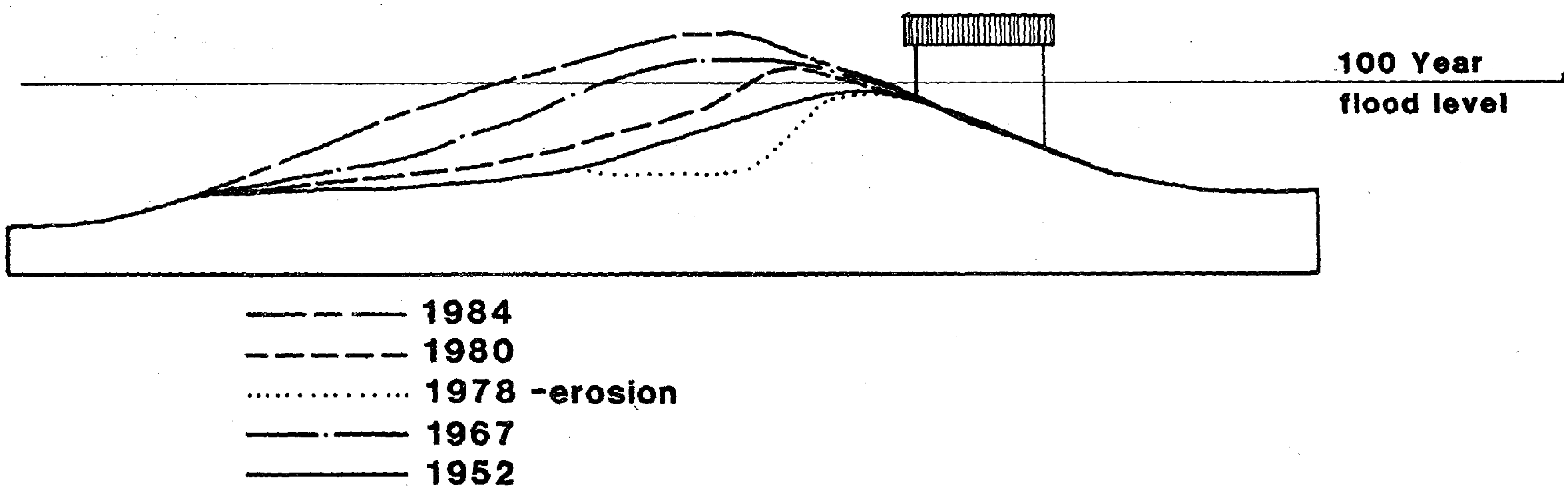
PLAN VIEW

SHORELINE CHANGES SOUTH OF NEHALEM BAY SOUTH JETTY



PLAN VIEW

GENERALIZED FOREDUNE CROSS-SECTION
CHANGES OVER 30 YEARS



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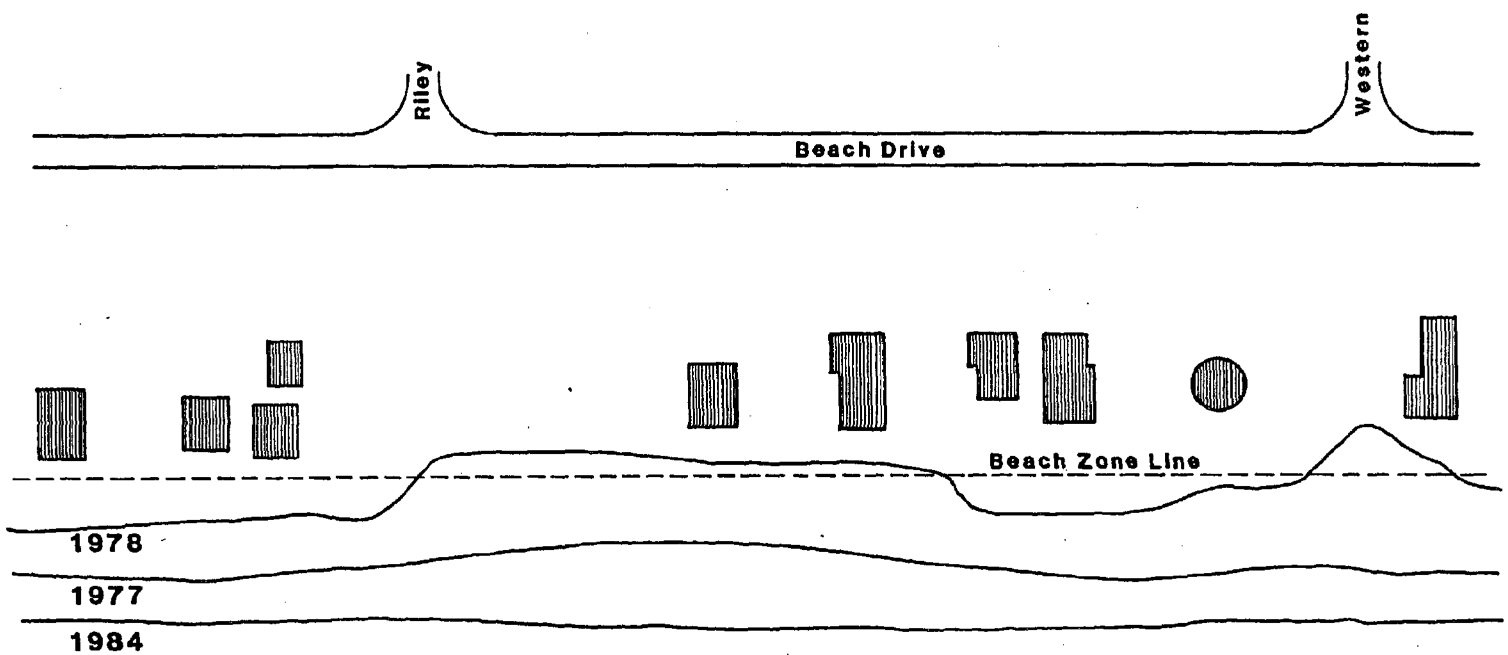
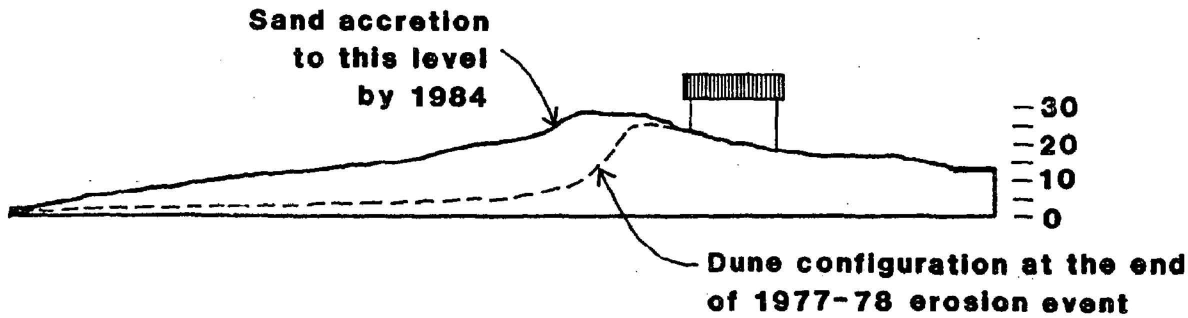
SHORELINE CHANGE AT NEDONNA BEACH



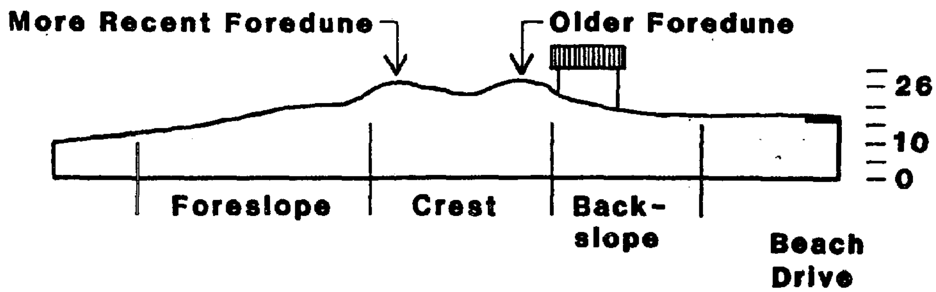
The 1978 line shows approximate upper extent of rip-rap placed in 1978.

COMPARISON OF 1978/1984 DUNE CROSS-SECTIONS



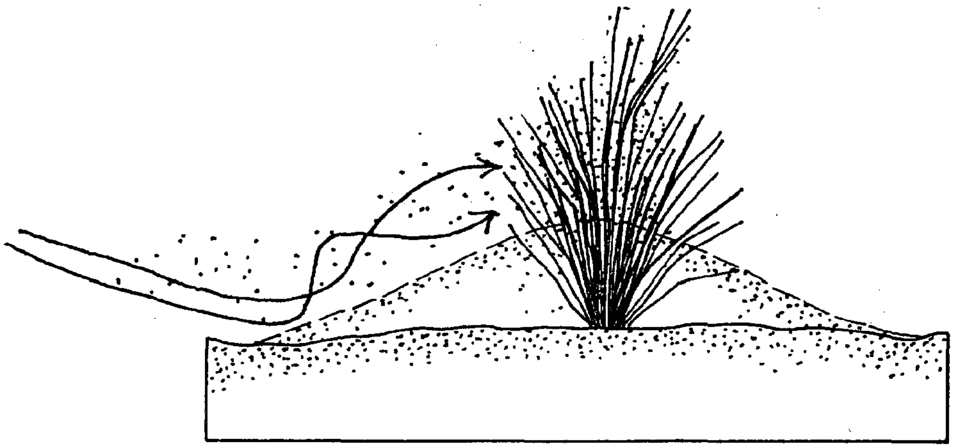
CROSS-SECTION OF DUAL FOREDUNE

From cross-section #23

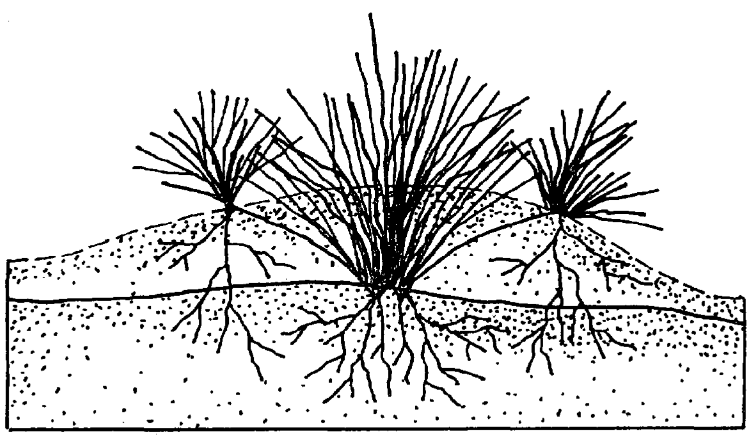


Note that older foredune is approximately the same height as 'newer' foredune.

HOW BEACHGRASS COLLECTS SAND



Sand deposition around a beachgrass windbreak.

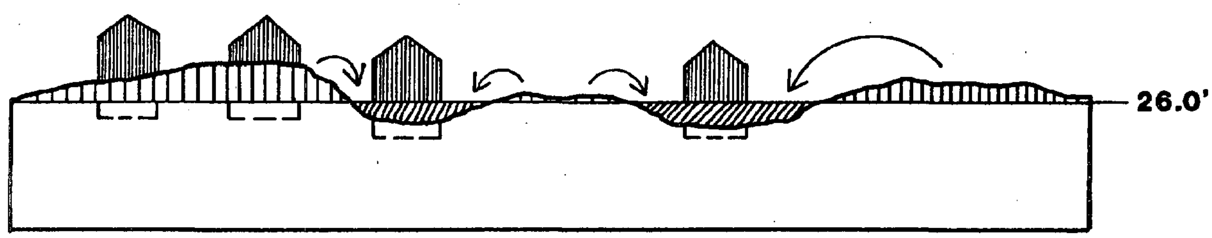


As beachgrass is buried, new shoots and roots develop at the dune surface.

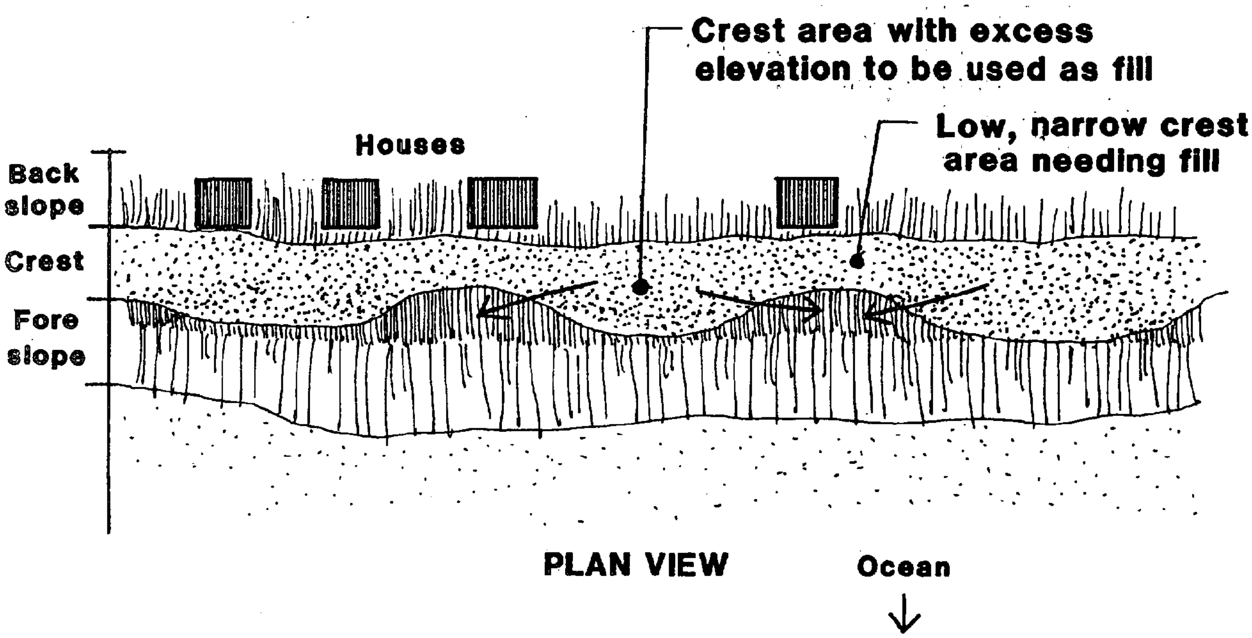
I-16

PLACEMENT OF GRADED SAND

PRIORITY ONE: Fill in low spots in crest to a minimum elevation of 26.0'



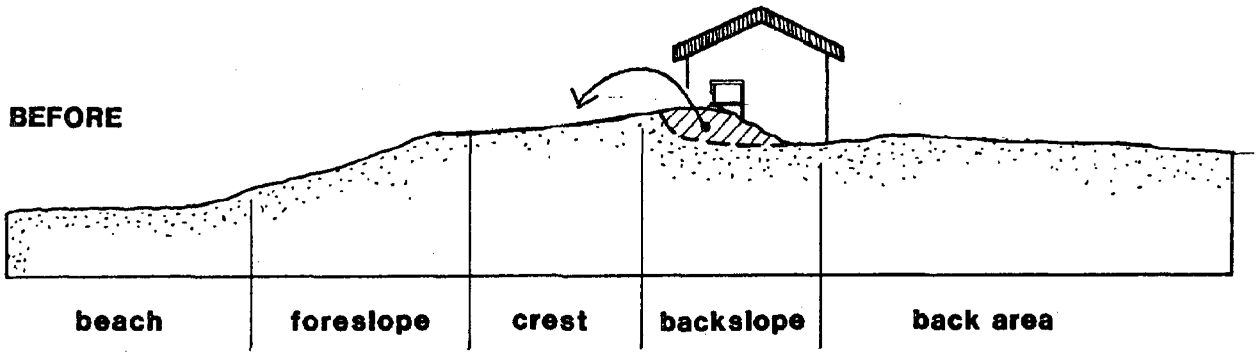
FOREDUNE CREST PROFILE



PLAN VIEW

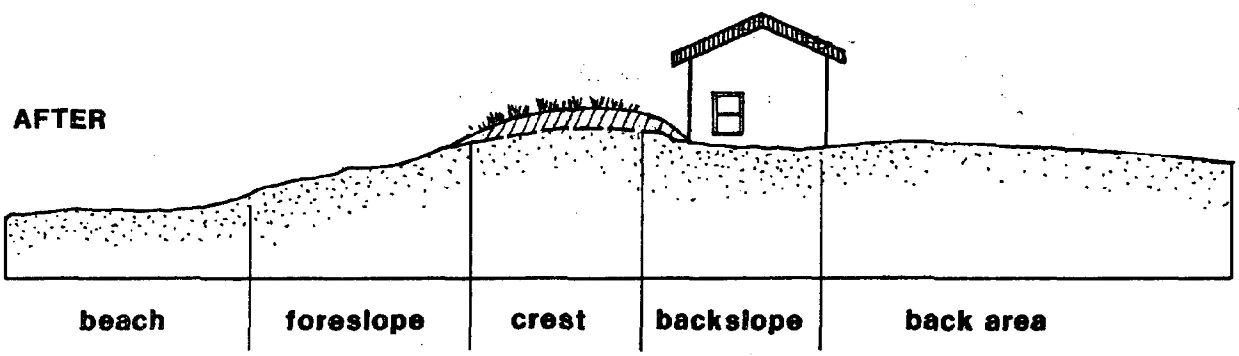
CLEARING OF SAND ACCUMULATIONS

BEFORE



NOTE: Only sand which is blocking doors or windows or access may be removed.

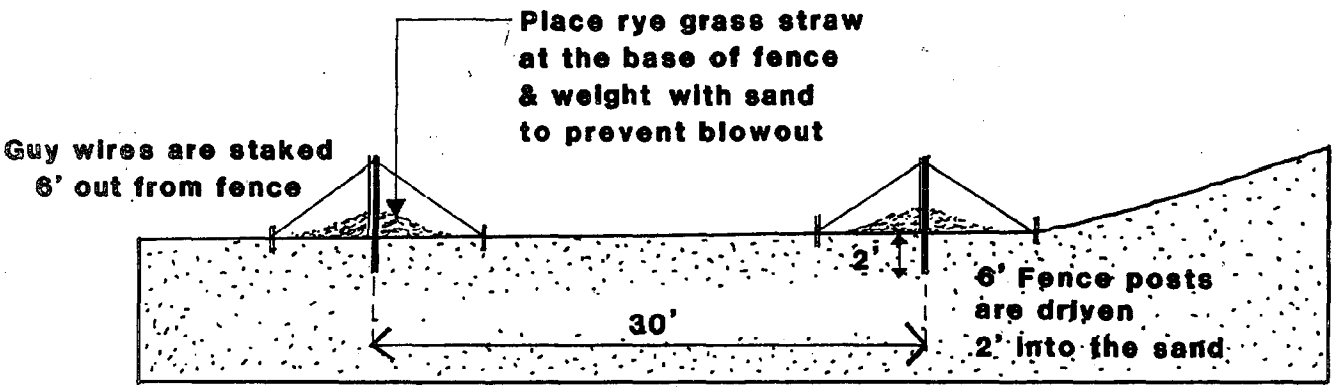
AFTER



Graded material should be placed on foredune crest and stabilized. Clearing sand from around structures does not include crest grading to create ocean views.

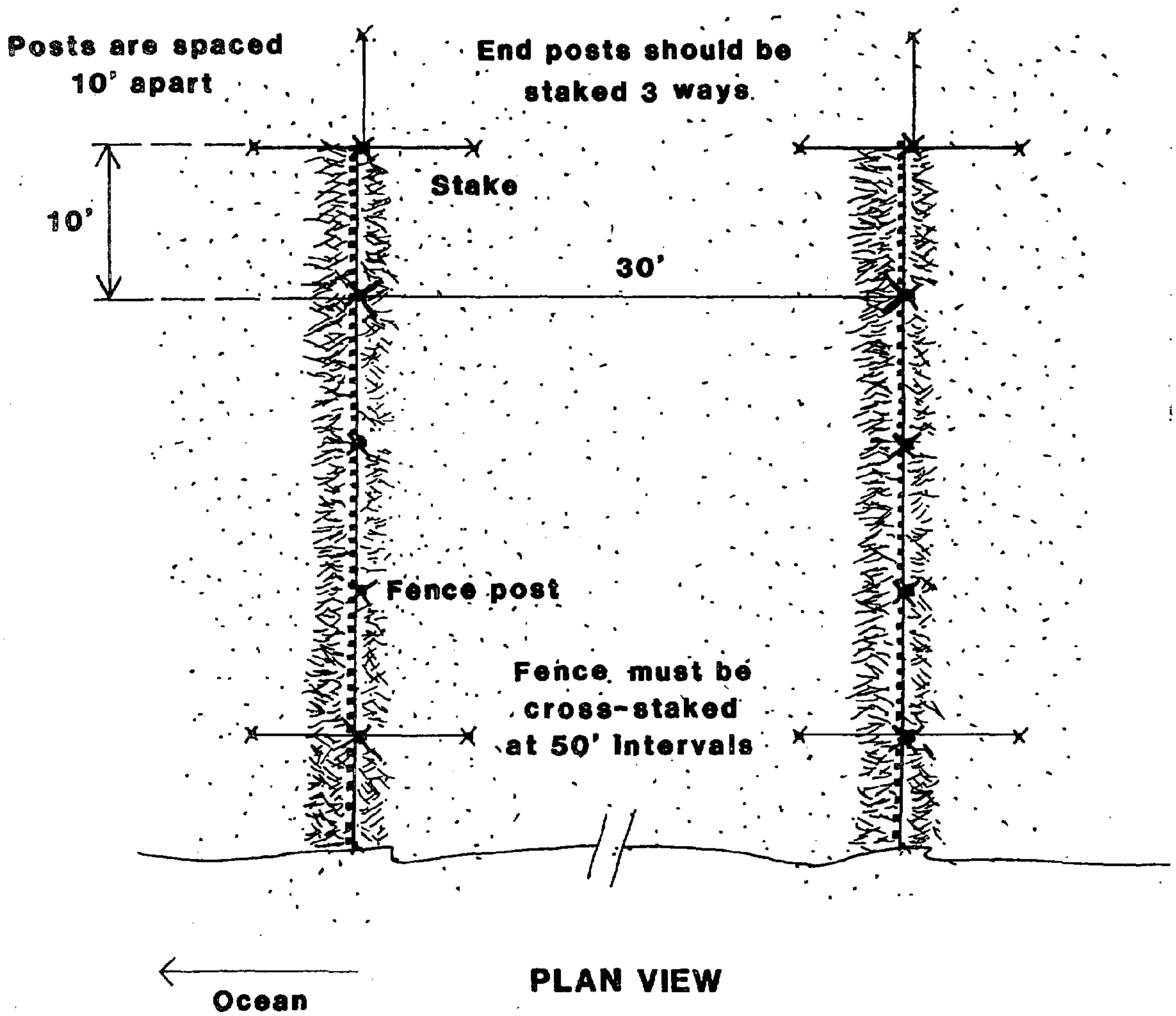
5-18

PLACEMENT & SPACING OF SAND FENCING



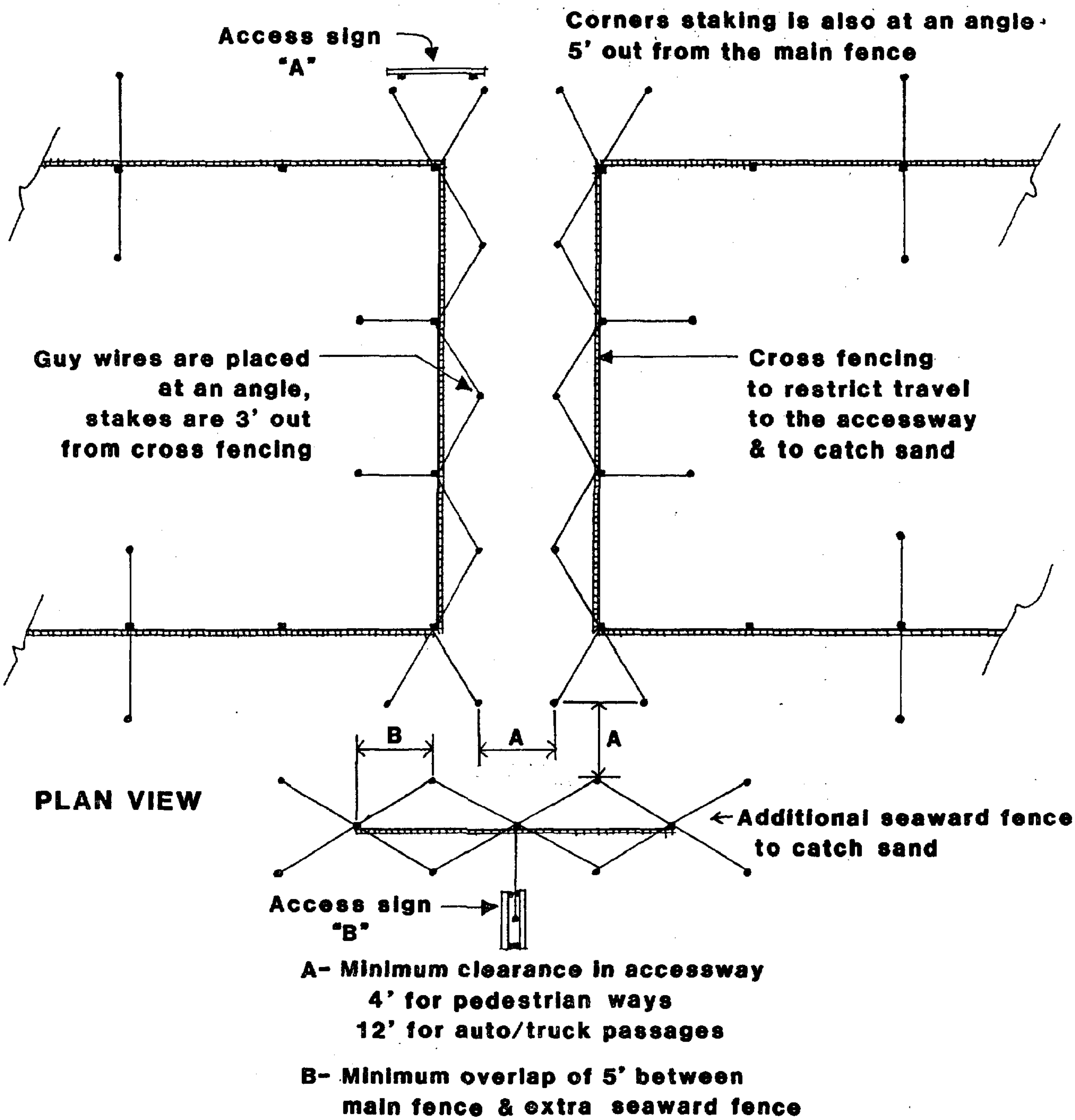
Two rows of sand fence are placed 30' apart

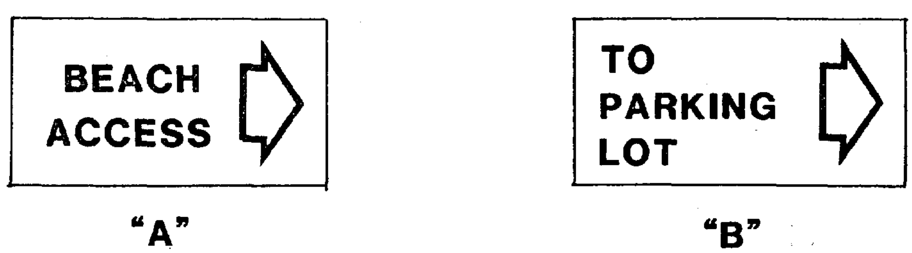
CROSS-SECTION VIEW

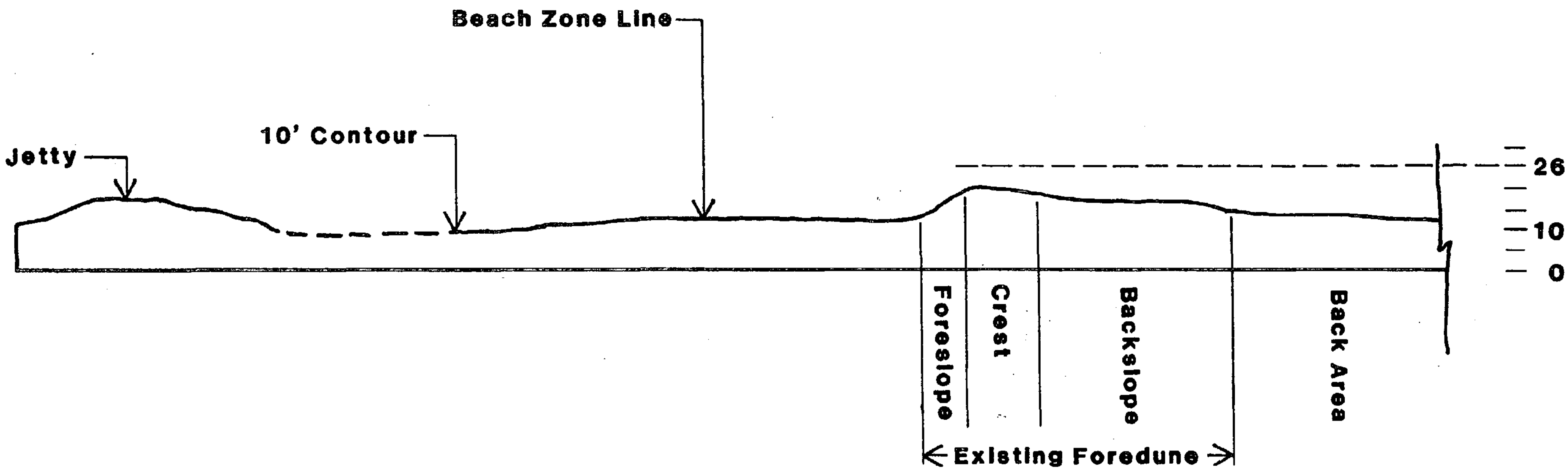


PLAN VIEW

ACCESSWAYS THROUGH SAND FENCING







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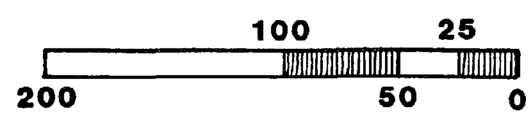

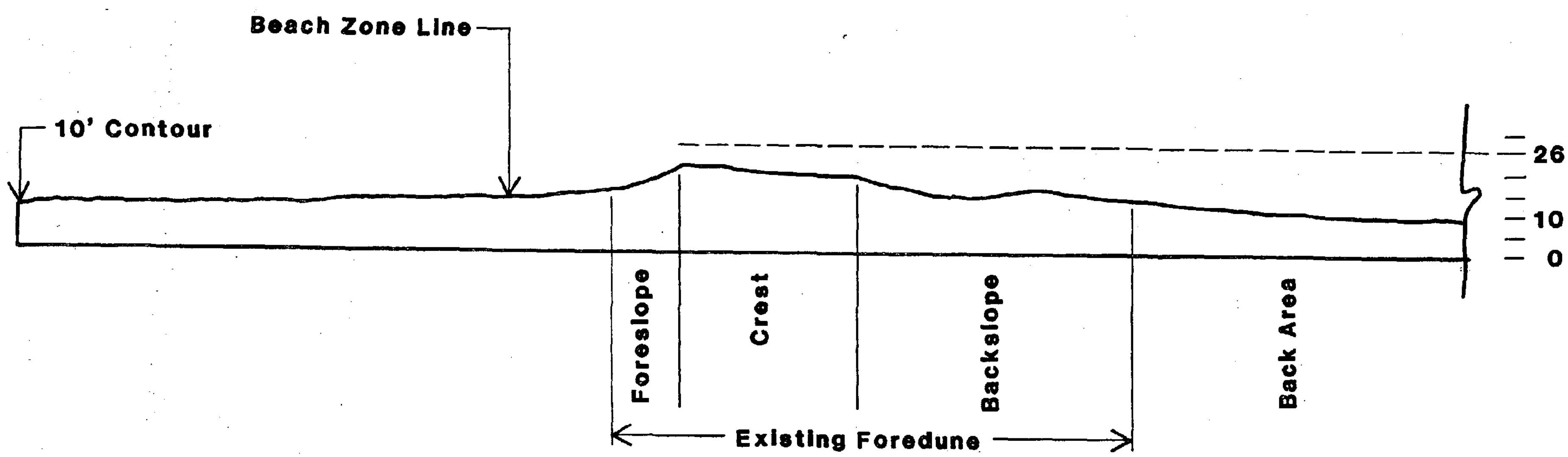

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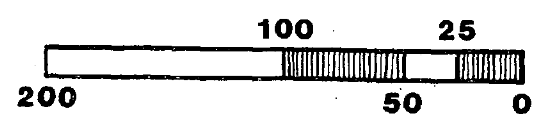

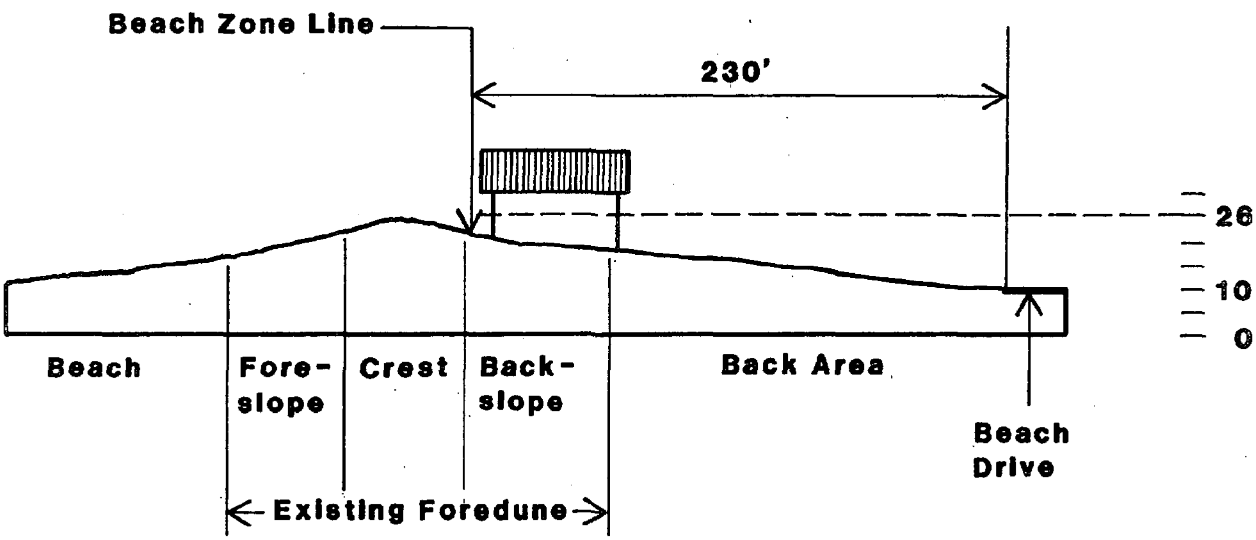

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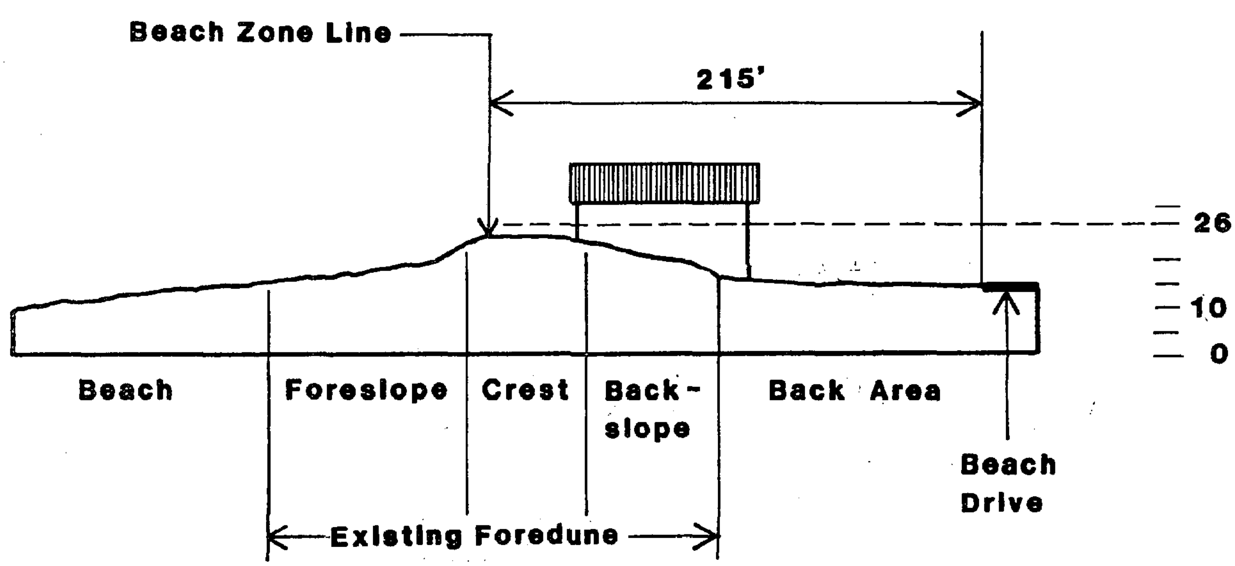

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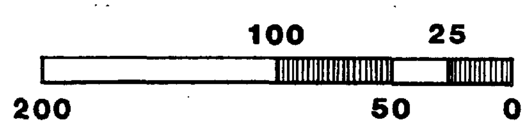

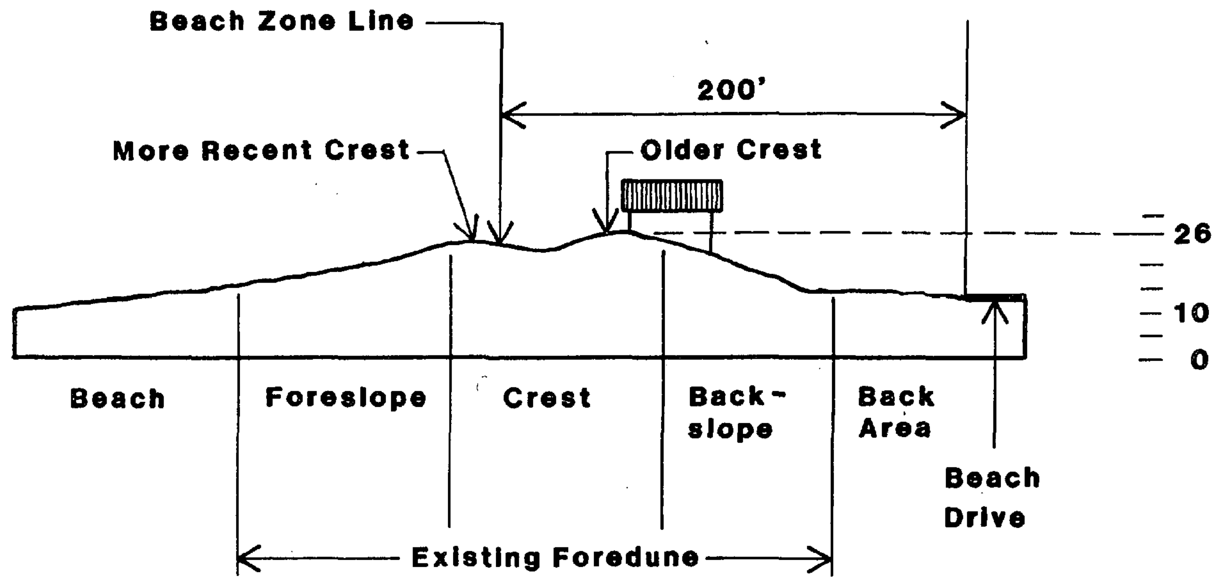

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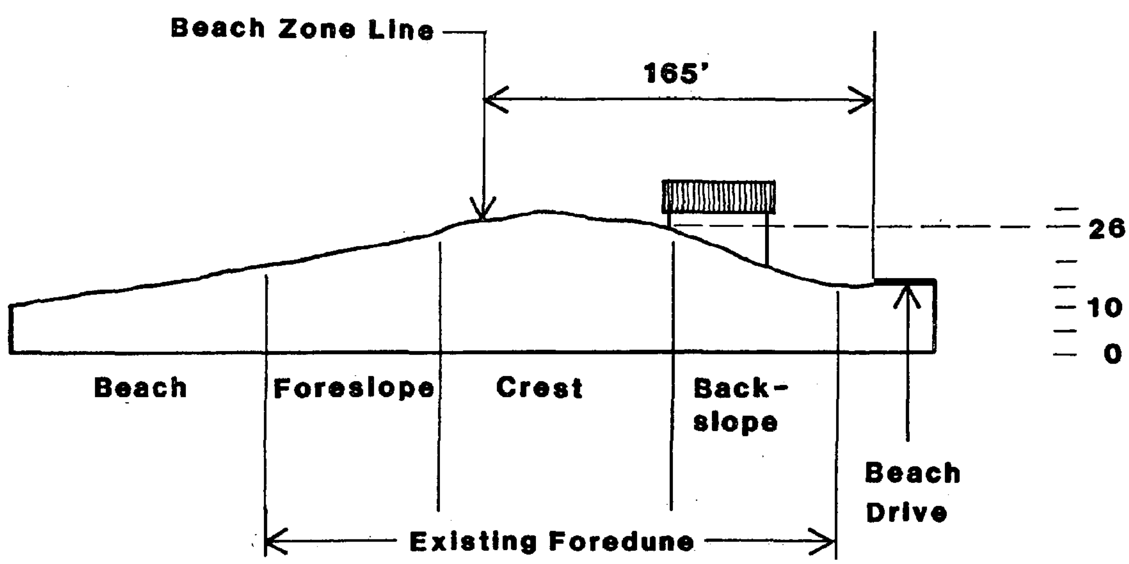

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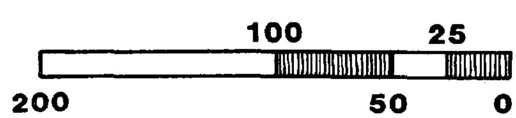

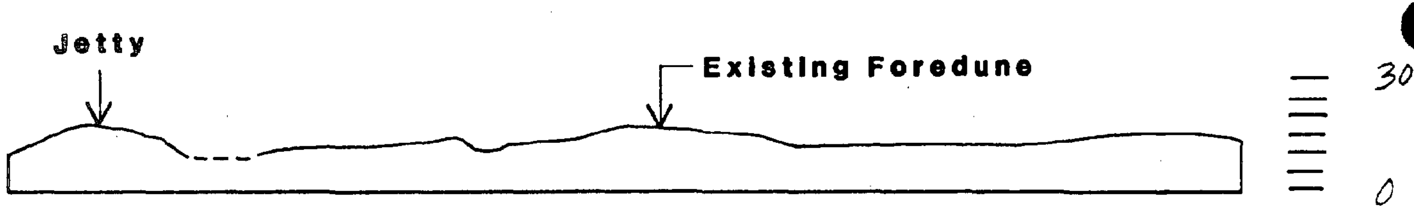

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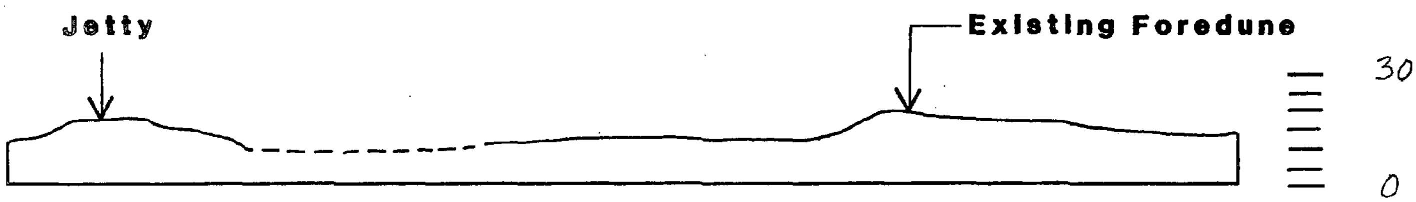

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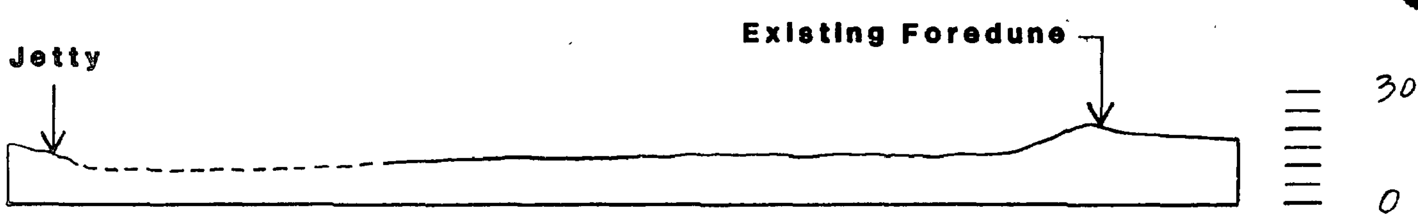

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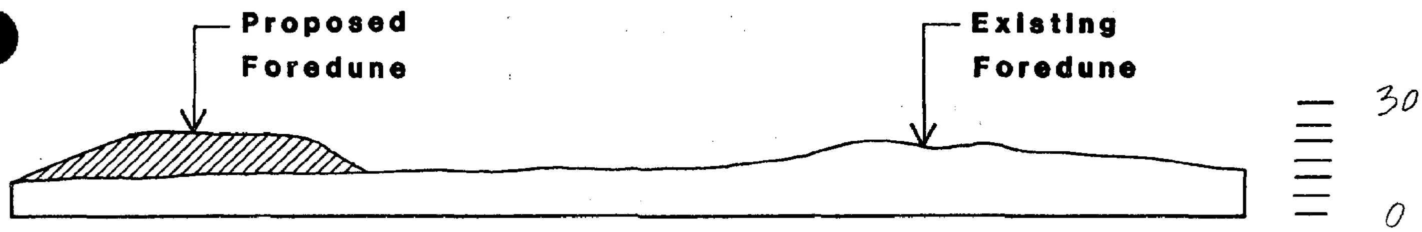
No. 4

NEDONNA BEACH GRADING PLAN CROSS-SECTIONS
(SUBAREA A: SOUTH JETTY)



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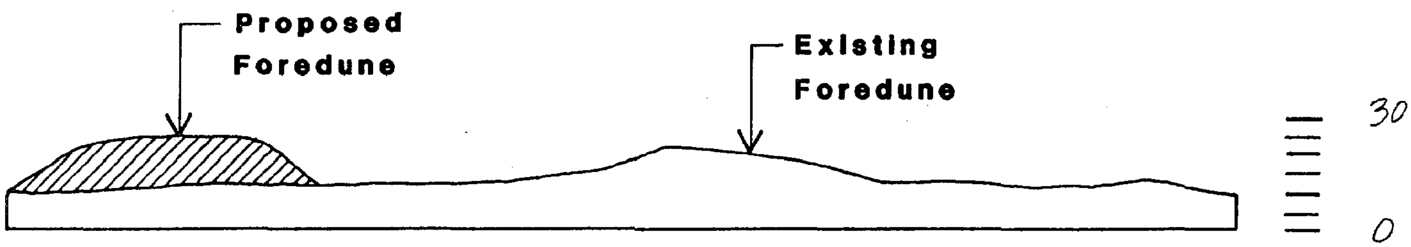

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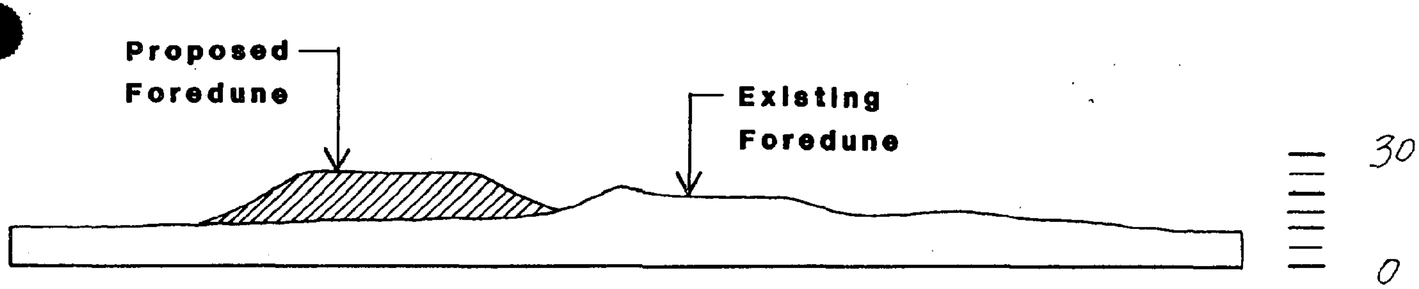

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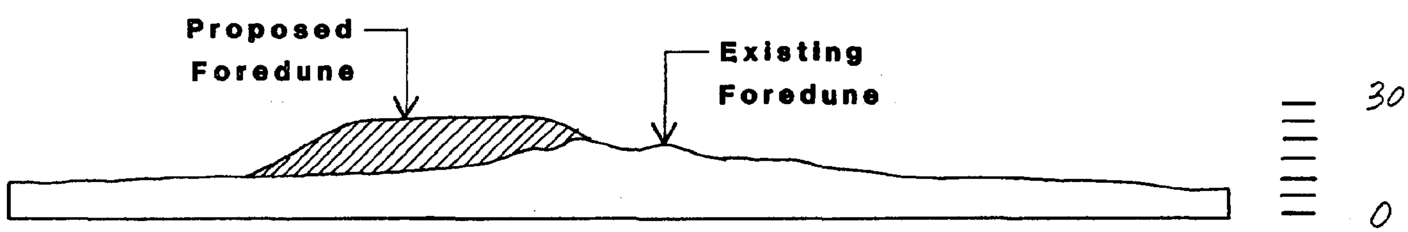

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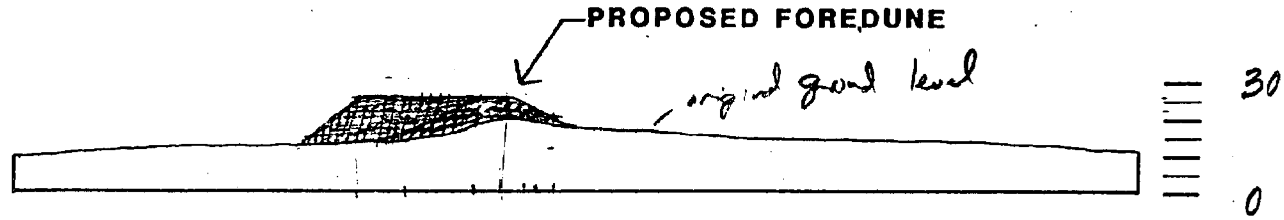
NEDONNA BEACH GRADING PLAN CROSS-SECTIONS

SOUTH JETTY / JETTY PARKING LOT



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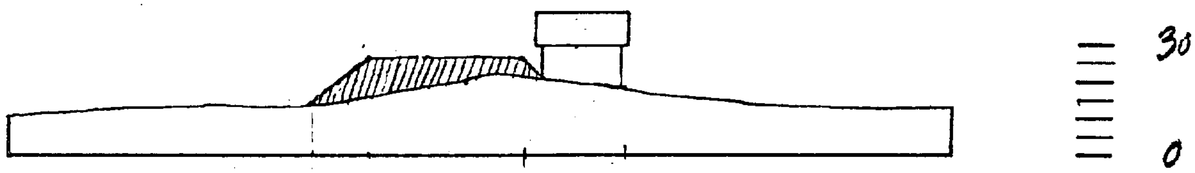

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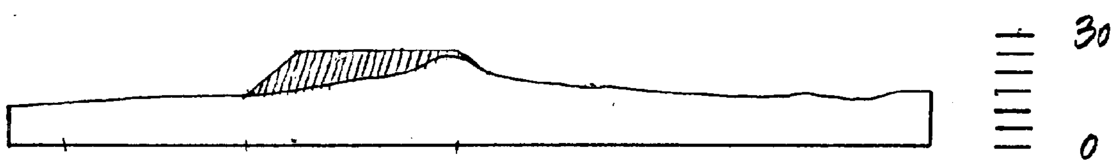

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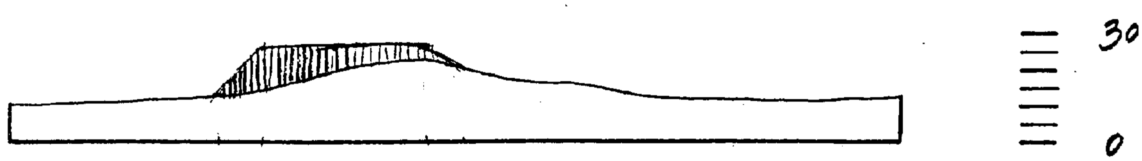

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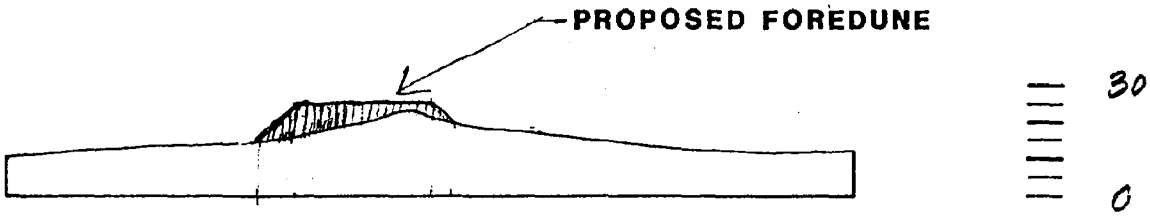
JETTY PARKING LOT / PARK ST.



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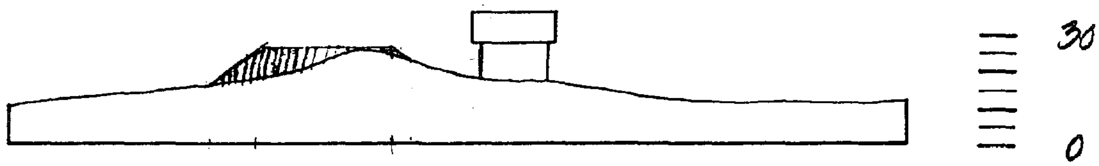

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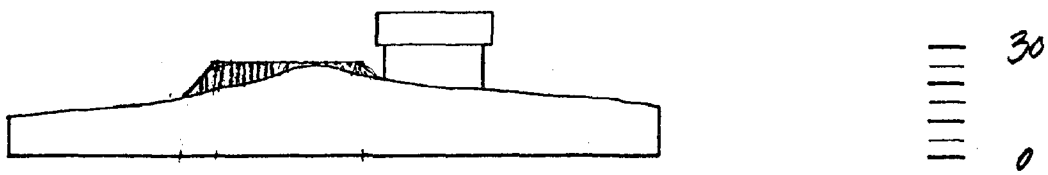

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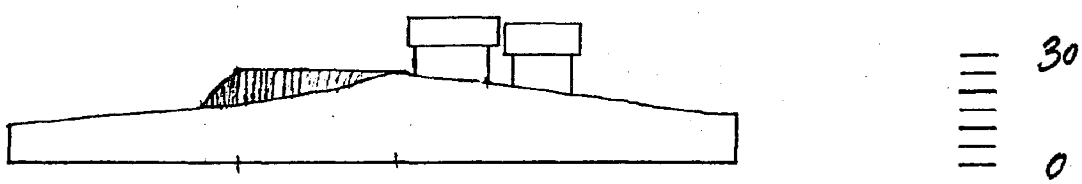

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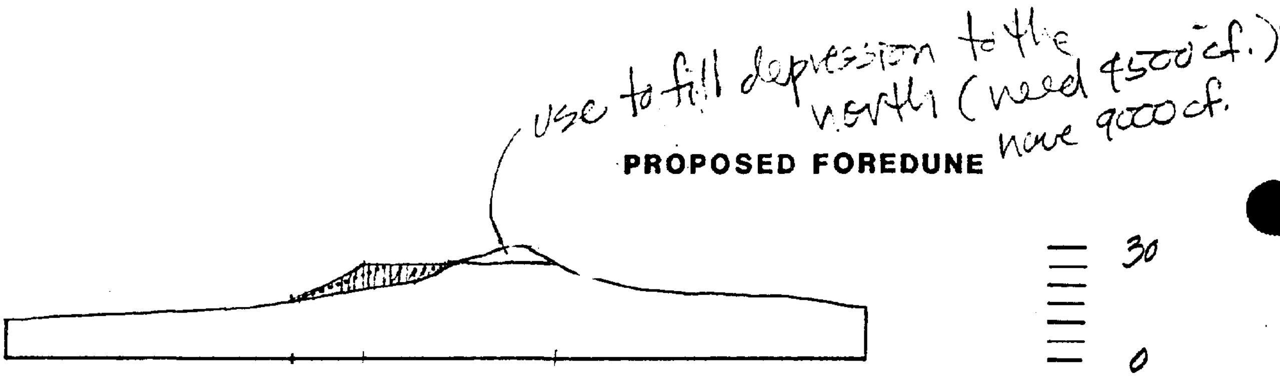
PARK ST. SUBAREA



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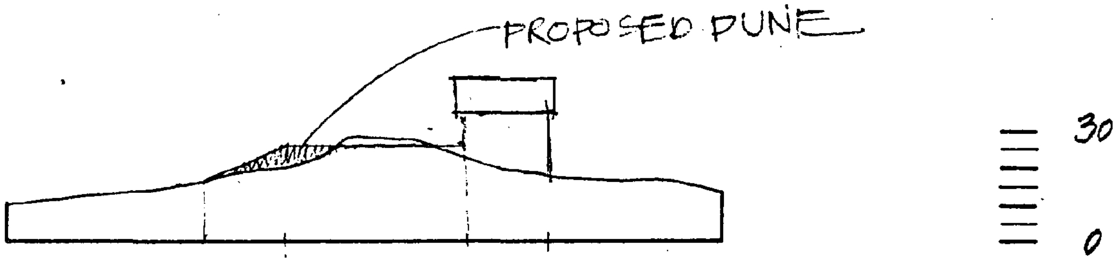

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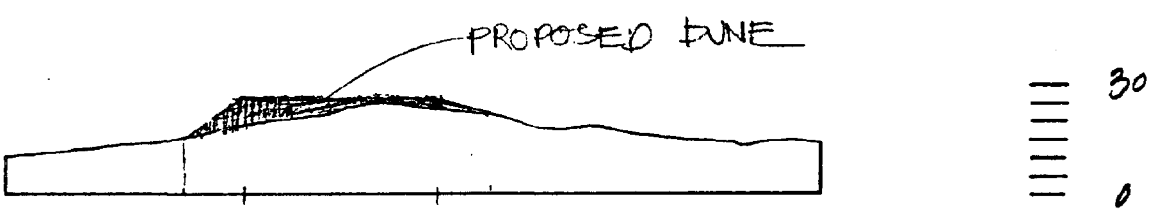

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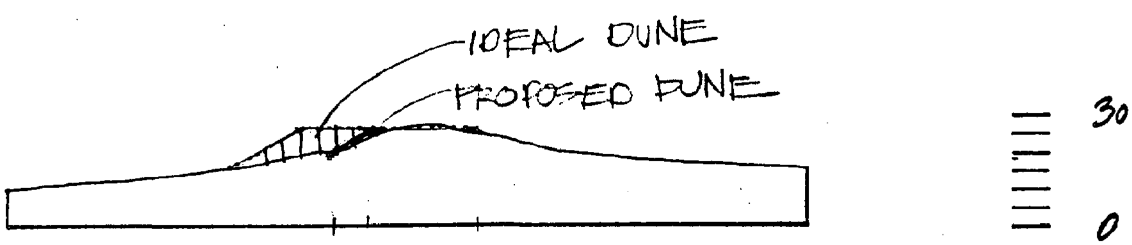

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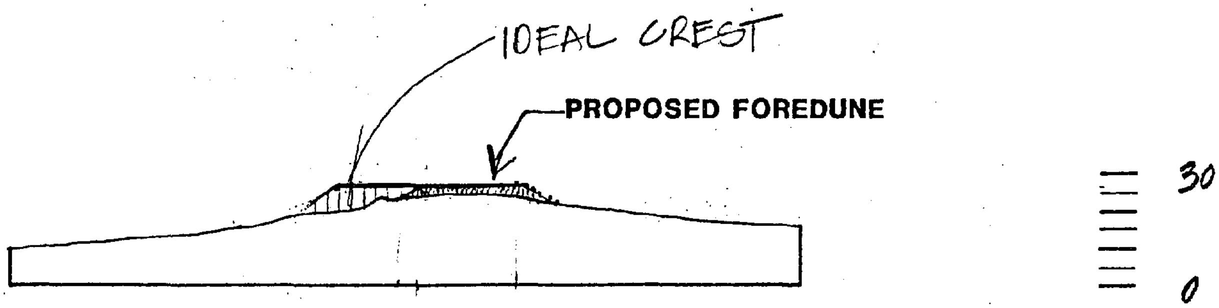
RILEY ST. SUBAREA



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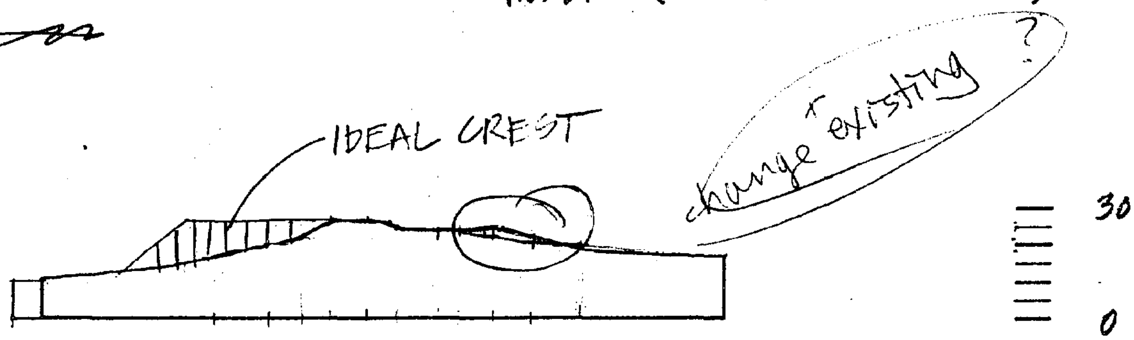

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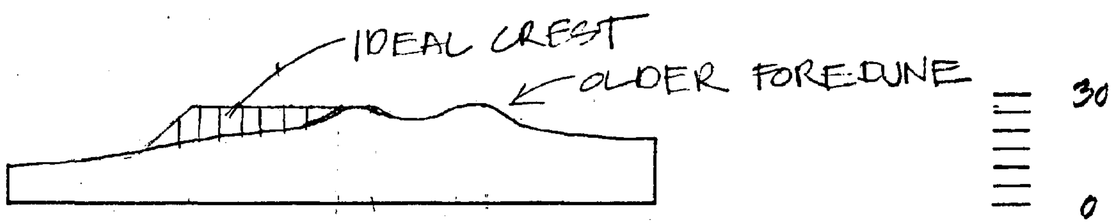

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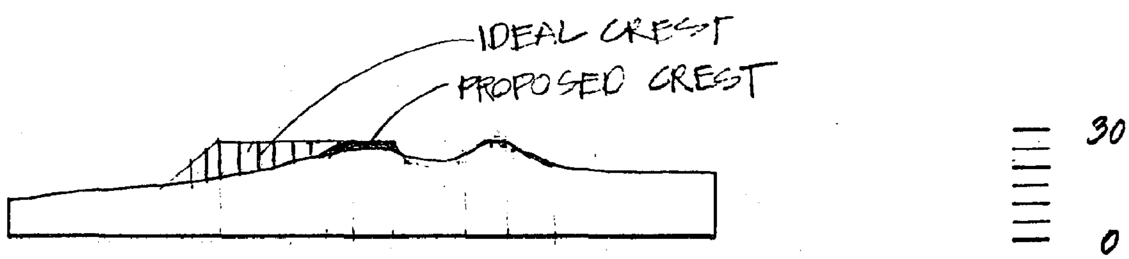
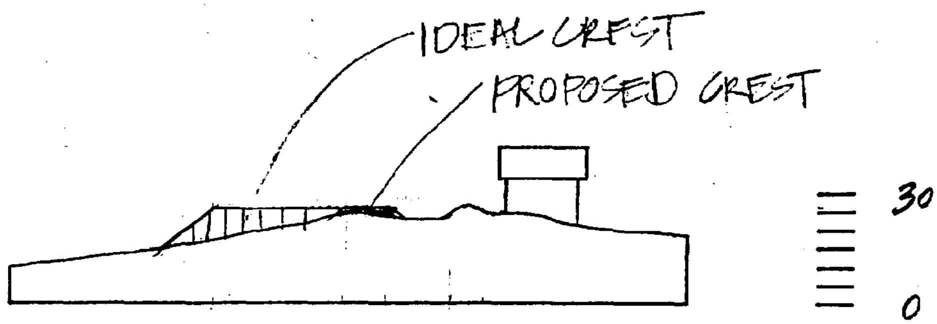


NO. 24

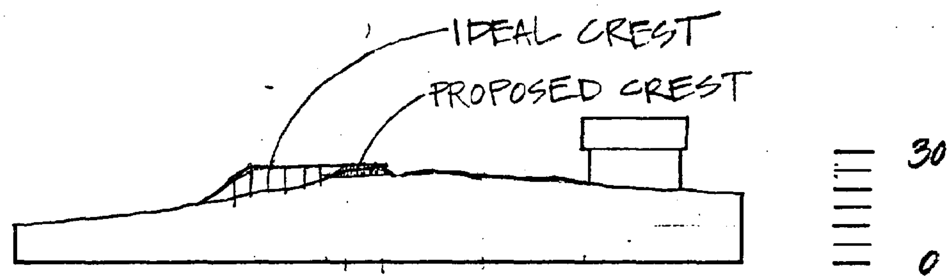
WESTERN ST. / SUNSET ST. SUBAREA



No. 25 (JUST No. of SUNSET ST.)

↑ Western/Sunset Subarea

↓ Lark St/Beach St. Subarea



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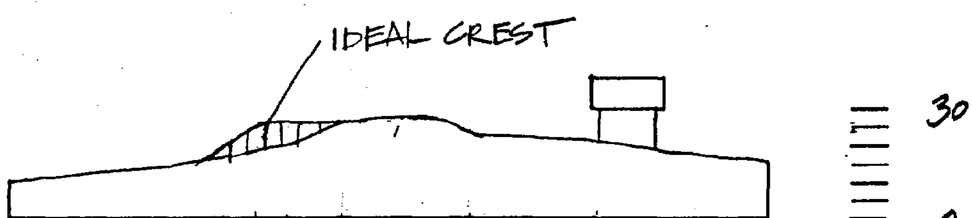

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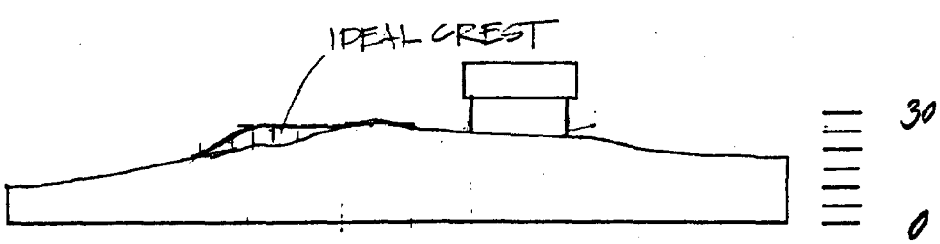
No proposed Crest?



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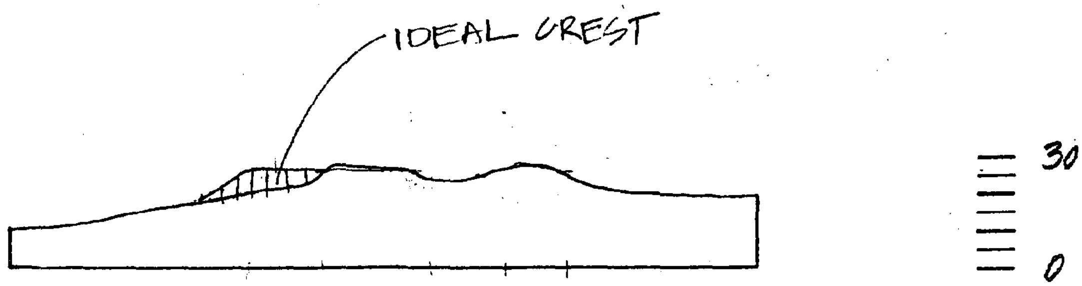
WESTERN / SUNSET — LARK ST / BEACH ST.



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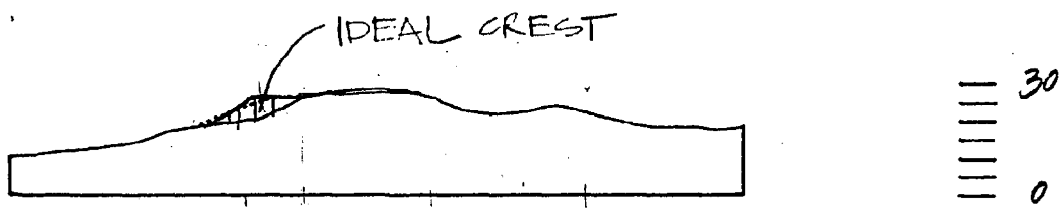

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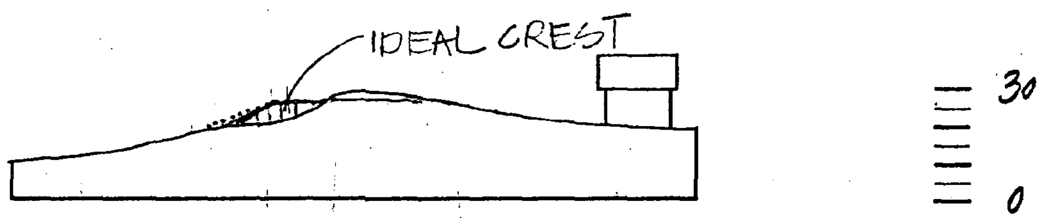

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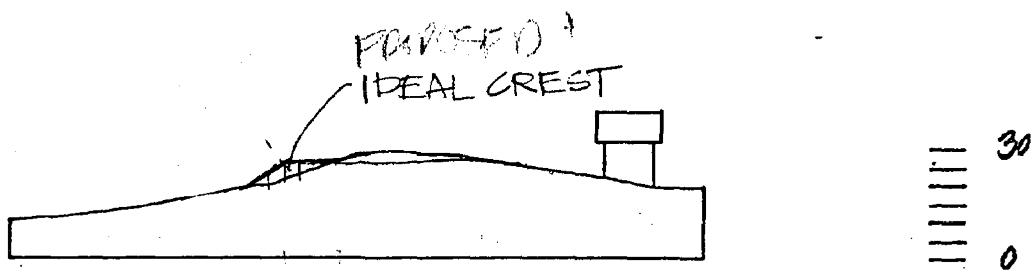

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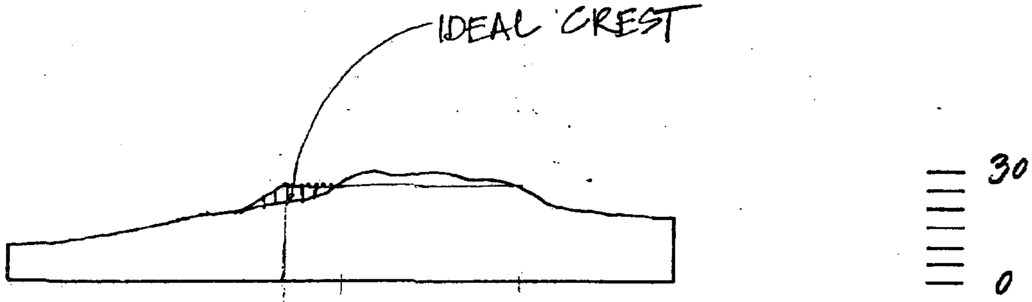
LARK ST/ BEACH ST. SUBAREA



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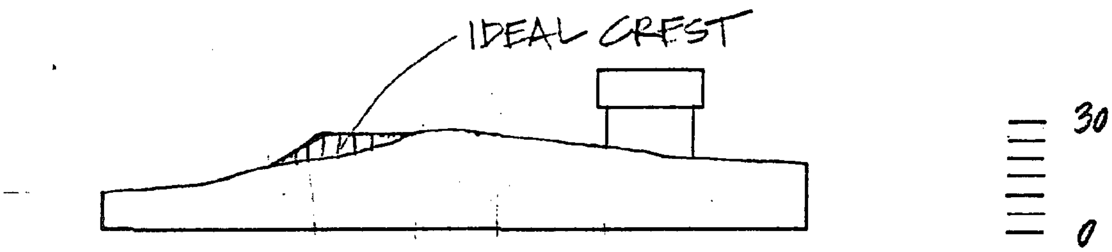

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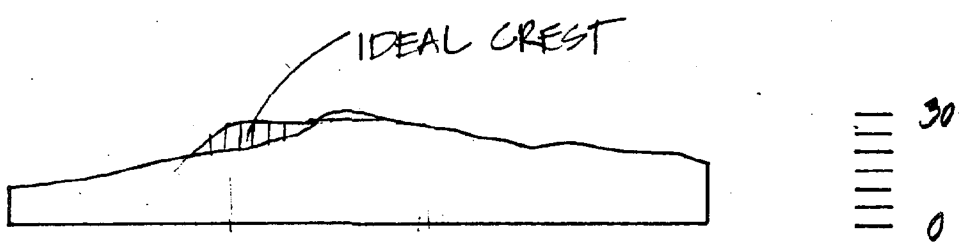

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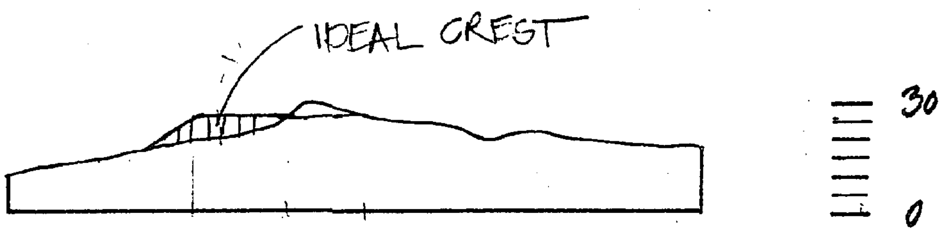

No. 36

LARK ST. / BEACH ST. SUBAREA

DEC 30 1986

Section 3.085: BEACHES AND DUNES OVERLAY ZONE

I. PURPOSE: The intent of this zone is to manage development uses and activities in beach and dune areas in order to:

(1) ensure the protection, restoration, and conservation of beach and dune natural resources;
(2) reduce the hazard to human life and property from natural events or actions associated with reasonable development of these areas;
(3) provide for dune grading or sand movement in foredune areas where an overall plan for managing foredune grading can be developed without reducing the capacity of these areas to provide flood and erosion protection;
(4) establish clear guidelines and criteria by which the natural hazards of beach and dune landforms can be assessed prior to development.

II. AREAS INCLUDED: The Beaches and Dunes Overlay Zone applies to the inventory of beach and dune landforms in Tillamook County, prepared by the U.S. Department of Agriculture, Soil Conservation Service and published in the 1979 report, Beaches and Dunes of the Oregon Coast. The dune areas mapped in the inventory are identified in the Goal 18 (Beaches and Dunes) Element of the Comprehensive Plan.
This overlay zone includes beaches, active foredunes, conditionally stable foredunes which are subject to ocean undercutting or wave overtopping, interdune areas that are subject to ocean flooding, deflation plains, younger and older stabilized dunes, and conditionally stable open sand areas.

III. CATEGORIES: The results of the inventory can be summarized into three categories of beach and dune shorelands:

CATEGORY(1)- DEVELOPED BEACHFRONT AREAS: Active foredune areas where an Exception to Goal 18 allows development on the active foredune. These areas are described in Section 5 of the Beaches and Dunes Element of the Comprehensive Plan.
CATEGORY(2)- FOREDUNE MANAGEMENT AREAS: Active foredune areas where an Exception to Goal 18 allows development on the active foredune and an overall management plan is approved to allow foredune grading. The management plans for these areas are contained in Section __ of the Goal 18 Element of the Comprehensive Plan.
CATEGORY(3)- OTHER BEACH AND DUNE AREAS: Beach and active foredune areas committed to resource protection or recreational use, and stabilized inland dune areas suitable for development.

IV. ADMINISTRATIVE PROVISIONS: Uses within the Beaches and Dunes Overlay Zone are subject to the provisions and standards of the underlying zone and of this section. Where the standards of the overlay zone and the underlying zone conflict, the more restrictive provisions shall apply.

A. USES AND ACTIVITIES PERMITTED WITH STANDARDS

1. Residential and Commercial Development

(a) Residential development and commercial and industrial buildings are permitted only on lots or parcels located in Developed Beachfront and Foredune Management Areas.

(b) Oceanfront dwellings shall be located as far landward of the crest of the active foredune as is physically or economically feasible to achieve an ocean view. At a minimum, structures shall be setback in line with dwellings on adjoining lots or parcels.

(c) Residential structures in active foredune areas shall be constructed to minimize future needs to remove inundating sand.

(d) Building heights shall be measured from the existing grade. Only in Foredune Management Areas shall additional fill be allowed on an oceanfront lot, provided the applicant can demonstrate that construction on the existing grade can not provide an ocean view and the provisions of Section 3.060 (Flood Hazard Overlay Zone) are met. The maximum amount of additional fill allowed shall be determined on a case-by-case basis by Tillamook County.

2. Private Beach Access

(a) Boardwalks and pedestrian footpaths to the beach shall be permitted in all dune areas, except where restricted in Foredune Management Areas.

(b) Off-road recreational vehicle use in Foredune Management Areas shall be restricted to beach areas. Access to the beach across active dune areas by recreational vehicles shall be restricted to identified public or off-road recreational vehicular access points.

(c) In Foredune Management Areas, where heavy use of public easements or rights of way destablizes dune areas on adjoining private property, signs may be placed at landward entrance points to encourage the use of alternative public access points. Signage shall be subject to review by the Foredune Management Authority and Tillamook County.

3. Beachfront Protective Structures

(a) Beachfront protective structures (riprap and other revetments) shall be allowed only in Developed Beachfront Areas and Foredune Management Areas, or where "development" existed as of January 1, 1977, or where beachfront protective structures are authorized by an Exception to Goal 18..

(b) Proposals for beachfront protective structures shall demonstrate that:

(1) The development is threatened by ocean erosion or

flooding;
(2) Non-structural solutions can not provide adequate protection.
(3) The beachfront protective structure is placed as far landward as possible;
(4) Negative impacts to adjoining properties are minimized;
(5) Existing public access is preserved;
(6) Construction standards in Section 3.140 (17) are met.

For the purposes of this requirement, "development" means houses, commercial and industrial buildings, and vacant subdivision lots which are physically improved through the construction of streets and provision of utilities to the lot.

Lots or parcels where development existed as of January 1, 1977, are identified on the 1978 Oregon State Highway Ocean Shores aerial photographs on file in Tillamook County.

c. The Oregon Parks and Recreation Division shall notify Tillamook County of emergency requests for beachfront protective structures. Written or verbal approval for emergency requests shall not be given until both the Parks and Recreation Division and the county have been consulted. Beachfront protective structures placed for emergency purposes, shall be subject to the construction standards in Section 3.140(17).

4. Foredune Breaching

a. Definition- In dune areas subject to coastal flooding, excavating the crest of a foredune below one foot above the base flood elevation constitutes foredune breaching. Lesser actions over a larger dune area also constitutes foredune breaching if the action increases the potential for ocean flooding in the surrounding area.

b. Foredune breaching shall be allowed in recreational beach and dune areas only to replenish sand supply in interdune recreational areas.

b. Foredune breaching shall be allowed in other areas on a temporary basis in an emergency (fire control, alleviating flood hazards or other diseaster conditions). For emergency vehicle access, foredunes shall be breached only after a demonstration is made that temporary access cannot be accomplished by the use of a fabric ground cover in combination with a crushed rock overlay.

c. Foredune areas breached shall be restored immediately following relief of emergency conditions and stabilized using permanent dune stabilization techniques. At a minimum, foredunes shall be restored to the pre-existing dune profile. Construction materials (rock, fencing, etc.) placed to accommodate emergency vehicle use or circumstances shall also be removed following relief of emergency conditions.

5. Accessory Structures and Uses

a. Accessory structures regulated by this section include, but are not limited to towers for communication facilities, garages, greenhouses, signs, boardwalks, windbreaks or other fences, and solar energy or wind conversion systems.

b. Accessory structures shall be placed either in locations established by plans for Foredune Management Areas, or in locations where there will be minimal interference to prevailing wind and sand distribution patterns.

c. Accessory structures shall not be permitted on crest areas of active foredunes, except for boardwalks which provide access across active dune areas to the beach .

d. Compliance with the provisions of Section 5.040 (General Provisions Regarding Accessory Uses) shall also be met.

6. Temporary Structures

a. Temporary structures regulated by this section include, but are not limited to boardwalks, windbreaks or other open-sided structures, and cabanas or similar structures.

b. Except for sand fences or boardwalks, temporary structures shall not be permitted in Foredune Management Areas where the Foredune Management Authority is restoring or stabilizing dune areas.

c. Compliance with the provisions of Section 5.150 (Temporary Uses) shall also be met.

7. Drift Log Removal

a. Cutting of driftwood for non-commercial firewood or other uses shall be restricted to identified areas, if required by a Foredune Management Plan. Otherwise, the removal of driftlogs shall be allowed only where it will not increase flooding or erosion hazards to existing development.

B. USES AND ACTIVITIES PERMITTED CONDITIONALLY

1. Public Beach Access

a. New public beach access points shall be allowed where identified in Tillamook County's Public Access Program to Coastal Shorelands, contained in the Goal 17 (Coastal Shorelands) Element of the Comprehensive Plan.

2. Commercial Drift Log Removal

a. The removal of driftwood for commercial firewood or other uses shall be allowed only if the removal will not result in increased ocean flooding and erosion hazards to existing development.

b. Permit approval shall be obtained from the Department of Transportation, Parks and Recreation Division.

3. Sand Mining and Mineral Extraction

a. Sand mining and mineral extraction shall only be permissible outside Developed Beachfront or Foredune Management Areas.

b. Sand mining shall be permitted in other beach and dune areas only where a geological investigation establishes that a historic surplus exists at the site and the mining will not impair the natural functions of the dune system near the site, including ground water circulation and littoral drift. Compliance with ORS 390.725 shall also be required.

4. Dredged Material Disposal

a. Shoreland disposal of dredged material shall be allowed only at approved sites identified in County Dredged Material Disposal Plans, except if the disposal is part of an approved ocean beach nourishment project.

b. Beach nourishment shall be designed to either offset the effects of active erosion or maintain a stable beach profile.

c. Proposals for beach nourishment shall demonstrate that:
(1) no new buildable upland is created;
(2) the sediment size and chemical characteristics of the material proposed for beach nourishment is substantially similar to the substrate in the beach nourishment area; and
(3) erosion of dredged material from the beach nourishment area does not result in adverse impacts to nearby estuarine or significant shoreland habitat areas.

C. SPECIAL ACTIVITIES PERMITTED WITH STANDARDS

1. Sand Stabilization

a . Definition- A program to stabilize a dune area, with regard to wind or water erosion, by planting sand-stabilizing vegetation either alone or in combination with the placement of sand fences.

b. Dune areas excavated for residential and commercial site development shall be stabilized within 9 months of the termination of major construction. In dwelling setbacks, fire-resistant vegetation, such as purple beach pea, shall be recommended as preferred vegetation in order to minimize fire hazards.

c. Mowing of beachgrass shall be permissible in all dune areas, except in foreslope areas of active foredunes where the foredune is actively accreting seaward.

d. Installing sand fences to build or restore foredunes shall be permitted in Foredune Management Areas according to specifications in Foredune Management Plans. In other dune areas, sand fences shall be allowed upon approval of Tillamook County and the Oregon State Parks and Recreation Division.

2. Foredune Grading

a. Definition- The alteration of a foredune, by mechanical redistribution or removal of sand, which results in a lower or more uniform dune height. Foredune grading actions, unlike foredune breaching, do not increase the potential for ocean flooding at the site.

b. Foredune grading shall be permitted only in Foredune Management Areas or in Developed Beachfront Areas. In these areas, grading shall be allowed only for siting a permitted use, for removing sand that is inundating a structure allowed by the underlying zone, or for dune restoration purposes where recommeded in Foredune Management Plans. Sand graded from foredune lots shall be relocated either on the beach, in low and narrow dune areas on site, or off-site at alternative beach and une areas.

c. Foredune grading to remove inundated sand shall be permitted only if there is no feasible or reasonable alternative method of sand removal. Inundated sand shall be disposed of seaward of existing structures and distributed in a manner that shall not impact adjacent dwellings. Graded areas shall be replanted within 9 months of grading activites, unless the graded area naturally reestablishes plant cover within the 9 month time period.

d. Grading to restore foredunes or to maintain ocean views shall be permitted only in Foredune Management Areas, according to Foredune Grading Plans included in the Goal 18 Element of the Comprehensive Plan. Grading in foredune crest areas shall only be allowed where the dune elevation is more than four feet above the hundred year flood elevation. At a minimum, Foredune Grading Plans shall describe standards for redistribution of graded sand by identifying low and narrow dune areas suitable for dune restoration, defining the appropriate timing of grading actions, and outline requirements for future monitoring.

V. SITE DEVELOPMENT REQUIREMENTS: Applications for development within the Beaches and Dunes Overlay zone shall comply with the following standards and requirements.

A. General Development Criteria

1. Groundwater and Deflation Plain Areas:

(a) The filling or draining of deflation plains shall only be permissible where a preliminary site report can demonstrate it will not lead to the loss of stabilizing vegetation, loss of water quality, or intrusiuon of salt water into water supplies.

(b) Prior to the approval of development using groundwater sources, a preliminary site report shall demonstrate that groundwater withdrawal will not lead to the loss of stabilizing vegetation, loss of water quality, or intrusion of salt water into water supplies.

2. Land Grading Practices:

(a) All sidehill roads and driveways shall be built entirely in cut-no-fill unless adequate structural support is provided.

(b) Excavated, filled or graded slopes in dune areas shall not exceed 30 degrees in slope. Surplus excavated material shall be removed off-site to a location where it will not constitute a hazard, unless low spots can be filled on site and adequately compacted to accommodate proposed uses.

(c) Proposals for development shall demonstrate that existing cleared areas are unsuitable for development. The removal of native vegetation shall be restricted to site preparation activities for placement of approved buildings or where required for the installatiion of utilities.

3. Drainage and Erosion:

(a) Temporary measures shall be taken to control runoff and erosion of soils during all phases of construction. Interception of storm water(roof and footing drains) shall be made in closed conduits and directed into adjacent roadways or drainages with adequate capacity to prevent flooding of adjacent or downstream properties.

(b) Plans for temporary and permanent stabilization programs, and the planned maintenance of restabilized areas, shall be provided by the applicant for areas disturbed during site preparation. At a minimum, areas cleared of native vegetation shall be identified on building plans and replanted within 9 months of the termination of major construction activities.

B. Beach and Dunes Hazards Report

1. Except in areas identified as older stabilized dunes, a Hazards Report shall be required prior to the approval of development within the Beaches and Dunes Overlay zone. The Hazards Report shall include the results of a preliminary site investigation and, where recommended in the preliminary report, a detailed site investigation.

2. Preliminary Site Investigation

a. The purpose of the preliminary site report is to identify and describe existing or potential hazards in areas proposed for development. The report shall be based on site inspections conducted by a qualified geologist, engineering geologist or soil scientist.

b. The preliminary report shall include plan diagrams of the general area, including legal descriptions and property boundaries, and geographic information as required below::

(1) identification of each dune landform (according to either the Goal 18 or SCS system of classification);
(2) history of dune stabilization in the area;
(3) history of erosion or accretion in the area, including long-term trends;
(4) general topography including spot elevations;
(5) base flood elevation and location of special flood hazard area boundaries;
(6) location of perennial streams or springs in the vicinity;
(7) location of the state beach zone line;
(8) location of beachfront protective structures in the vicinity;
(9) elevation and width of the foredune crest.

Elevations shall be reported in relation to the National Geodetic Vertical Datum of 1929, NGVD.

b. The preliminary report shall either recommend that a more detailed site investigation report is needed to fully disclose the nature of on-site hazards or conclude that known hazards were adequately investigated and state what development standards be adopted for buildable areas..

2. Detailed Site Investigation-

a. The purpose of the detailed site investigation is to fully describe the extent and severity of identified hazards. A detailed site investigation shall be required either where recommended in the preliminary site report or when building plans, including grading plans for site preparation, were not available for review as part of the preliminary site investigation. The detailed site report shall be based on site inspections or other available information and prepared by a registered civil engineer or engineering geologist.

b. The detailed site report shall recommend development standards to assure that proposed alterations and structures are properly designed to avoid or recognize hazards either identified in the prelimimnary report or as the result of separate investigations. The report should include standards for:

(1) development density and design;
(2) location and design of roads and driveways;
(3) Land grading practices, including standards for cuts and fills and the proposed use and placement of excavated material ;
(4) vegetation removal and a revegetation plan;
(5) special foundation design (for example spread footings with post and piers), if required;
(6) management of storm water runoff during and after construction.

3. Summary Findings and Conclusions-

The preliminary and detailed site reports shall include the following summary findings and conclusion:

(a) The type of use proposed is reasonably protected from the described hazards for the lifetime of the structure;
(b) The type of use proposed and the adverse effects it might have on to life, property, and the natural environment;
(c) Measures necessary to protect the surrounding area from any adverse effects of the proposed development;
(d) Periodic monitoring necessary to ensure recommended development standards are implemented or monitoring necessary for the long-term success of the development.

DATE DUE

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